Chemical Exposition Daily, Sept. 27

CHEMICAL & METALLURGICAL ENGINEERING

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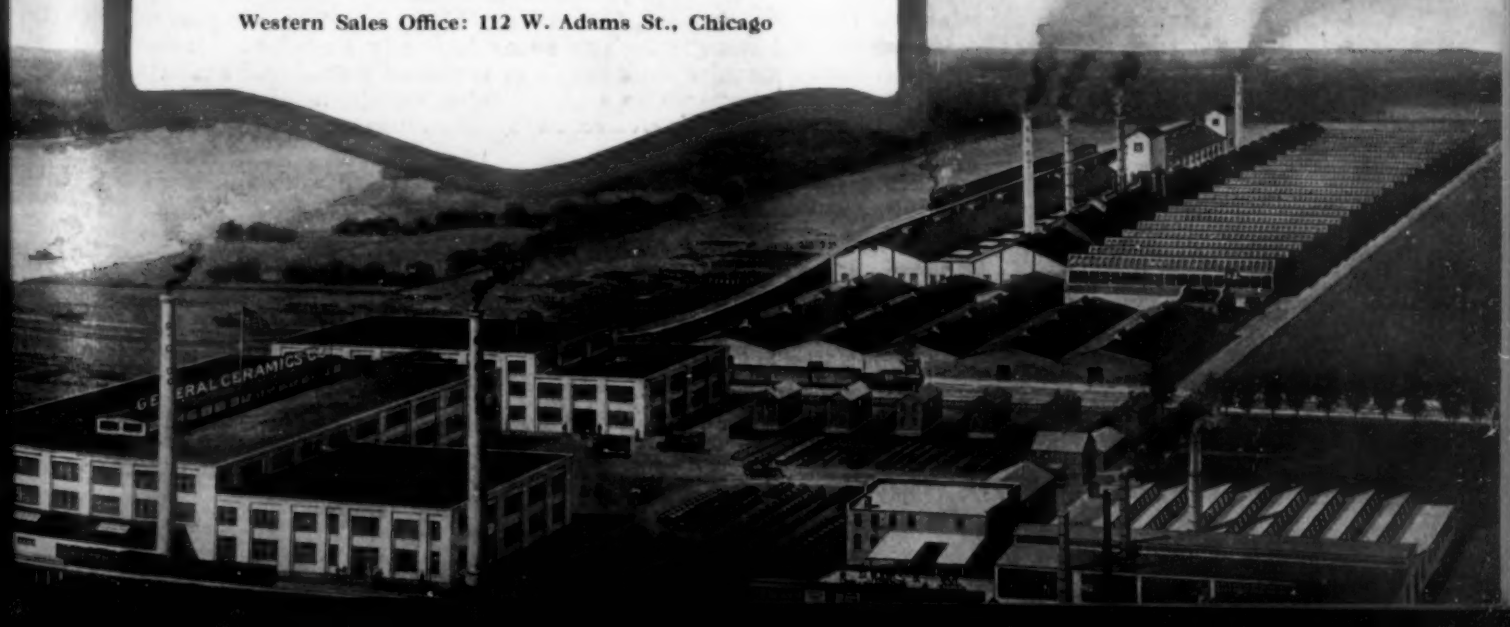

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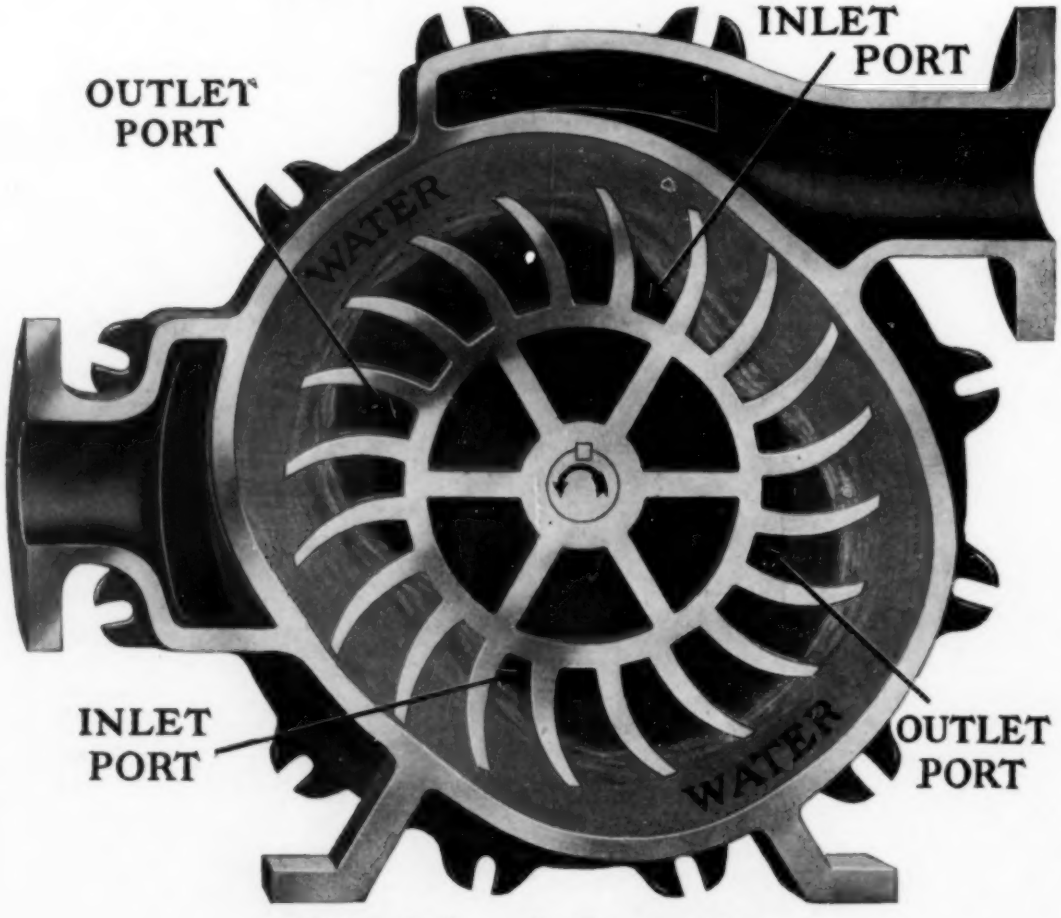

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The Exhibit of the Ceramic Section

TIME was when "Jena" and "Royal Berlin" were names to conjure with, and "Made in Berlin" was a sign of excellence which we now know can be achieved by other than Teuton ceramists. A visit to the ceramic section of the Exposition will convince one that the declaration of ceramic independence has been written for the United States, and that our brands of glass and porcelain ware are now free from the stigma of foreign antecedents.

The achievement constitutes one of the romances of the war. Prior to 1914 it was so easy to secure good laboratory glass and porcelain from Germany that nobody seriously considered domestic production. Schools and colleges got their supplies duty-free, and commercial organizations did not have to pay high prices. So thorough was our dependence that the industry had to be built from the bottom when war disturbed our customary imports.

Of course the country was not without potters and potteries, but their direct experience with laboratory porcelain was not extensive. Also we had glass works, but our brands of laboratory glassware had been regarded as inferior. The abstract of the census of manufactures for 1914 makes no mention of laboratory porcelain; nor does chemical glassware achieve the distinction that is given to nest eggs.

The problem was not too difficult for American manufacturers, however, and to-day's result is laboratory ware of excellence. This issue of CHEMICAL & METALLURGICAL ENGINEERING is a complete story of American ceramic independence. The various authors emphasize the possibilities of American raw materials and demonstrate the satisfaction rendered by the finished products. Their remarks should arouse a feeling of pride in every American chemist.

American Clays and Ceramics

THE clay products industry is perhaps the most ancient and honorable of the chemical allies. Vases and urns of a considerable degree of fineness are constantly being found in the burial mounds of the prehistoric inhabitants of our hemisphere. The art appears to have originated in Asia and the fact that the aborigines of America knew it well indicates that there is some kinship between the Indians of Columbus and the oriental peoples. Upon the landing of the colonists in America, ship traffic was such that bricks and other clay products offered the most convenient form of return ballast, so that buildings along our coast from

Portland to Galveston were built of English brick. However, as our pioneers penetrated farther and farther into the forest, imported bricks became a burden, and with the pottery of the Ohio Indians showing what could be done, it was only natural that the ceramic industry should eventually be started. However, the colonial potter had been schooled to European methods and recipes, so that while he freed us of imported bricks, he subjugated us to foreign clays wherever the product would stand the freight.

With the recent interruption in ocean traffic and German imports, a much needed punch has been put into our ceramic industries. Foreign clays and clay products were stopped with a bump. The wheels of the industries began to turn faster than ever before. Ceramists had to get busy and contribute their share. How admirably the requirements have been met are exemplified at the Fourth National Exposition of Chemical Industries. From bricks to aëroplane engine spark plugs is a long trip, but the journey has been made at a finish pace that will break the world's records for speed.

The one great need for the acquisition of perfection in ceramics is the proper understanding of the science involved in the art. Chemical and physical properties cannot be studied independently. The requirements of the scientists in this field are so great and the technology so rich, that the American Ceramic Society is going to issue a journal. That greater progress is to be expected by this infusion of modern science into ancient ceramics goes without question from the results of the short period just past. American chemical porcelain ware will go down into the history of our industries with honors.

Economics in the Works

SOME time ago we were called upon to examine into a long established industry. We were expected to admire, but we found nothing to praise. The leaders were men of eminence, many of whom had made comfortable fortunes while some had achieved great wealth. Wages were high even in normal times, and we were expected to show amazement and wonder and delight at the city's pride. But we did not. There was neither coöperation nor coördination nor research to be observed. There were wastes that might have been decreased at nearly every turn and there were opportunities to reduce the time factor in many processes, but the owners had no apparent interest in discovering them. Whether they believed in research or not they certainly did not encourage it. They were willing to let some other fellow pay for experiments.

We are trying very hard to do our share in the development of chemical statistics, but statistics require records, and the unprogressive manufacturer is conservative and declares that he is unwilling to publish his business secrets. In most cases he would be ashamed to have them known. From the census we can gather the production of raw materials and the gross products manufactured from them, but these estimated yields are incomplete and they constitute at best but *ex post facto* information. We can only compute the economic standing of an industrial establishment when we consider the theoretical yields and compare them with its actual achievements.

It may not be profitable to publish such figures, but it is remarkably unprofitable not to know them. And yet how many manufacturers today know the relation of the performance of their works to the theoretical yields? We venture the opinion that the percentage is small, although this information is a proper accompaniment to cost-accounting, because it serves as a constant check upon neglect. Too often we have known manufacturers, who through ignorance and neglect were unable to attain the same yields as the more enlightened foreign competitors, to appeal to Congress for tariff duties to protect them against their own shortcomings. We venture the opinion that no manufacturer should have standing before the Tariff Commission who is unwilling to confess his yields.

If the waste is known to be excessive, where is it? How much of it is unnecessary? If it is in the materials, in which one is the fault, and what is the fault? How may it be corrected? Again, if the laboratory control is fair and the loss is unwarranted by good practice, the chances are that there is defect in supervision, because the workmen are not adequately trained. But that again is usually less the fault of the laborer than it is of the master, whose business it is to educate his men rather then to instruct them.

A man who is educated to perform his work knows the reason for every act. He becomes the master of the materials entrusted to his charge, and he knows what to do. If he is a good man he will want to learn, and he is less likely to make mistakes. The one who is instructed merely knows, for instance, that he must turn a cock off or on when something happens, and that is all he ever does know. The same attention is not to be expected from him as from the man who knows why he should do it and just what is happening. It is very important that this kind of education proceed apace in this country. In Germany, before the war, it was easy enough to have a specialized chemist in technical charge of every process. The workmen were organized under pseudo-military discipline and the Herr Doktor would utter *das Kommando* which the men would obey.

We cannot afford to maintain so large a professional faculty for the same amount of work in America. We doubt also if many American employers could stand that number of German chemists in their establishments, and American chemists won't work for the price. Moreover, we know very well that American workmen would not endure the *Kommandos* of the German chemists. We must, therefore, to come out even, educate our workmen to do a good part of that which was done by the German *Betriebschemiker*. This takes time and patience and good-will.

Chemical manufacture in America requires therefore first of all, familiarity with and practice of research. It demands also constant study of actual as compared with theoretical yields. It needs more intensive study of processes and consequently a broader understanding of their nature by the technical director of American works than was needed by a man in the same position in Germany, because the American technical manager cannot have as many graduated assistants. And provision must be made for the intelligent education of the workmen. Mere instruction is not enough.

Sidelights on the Exposition

Among the whirling and moving exhibits is that of the Raymond Impact Pulverizer Co. of Chicago which shows a full-sized automatic pulverizer and ¼-size mill, pulverizer and separator, all in operation. To carry conviction they separate hominy and cork-dust and the exhaust fan from their cork-dust pulverizer blows right into the exhibit without messing things up. Each piece of apparatus is provided with windows to show what is happening inside. That is a good plan, whenever it is possible.

* * *

One of the chemical colonels who visited the exposition told of a cootie-killing device that has been proposed which does the work by means of high-frequency currents. Tests that have been made thus far prove very favorable. One difficulty which the authorities met in their preliminary work was to have the desired number of cooties in one place for the necessary animal experimentation and to avoid, at the same time, any untoward distribution of them. The situation has been met by a good and patriotic man, too advanced in years for the draft, who is doing his bit by providing his own and proper person as host for the lively *pediculi*. These are herded, if we may use the term, within rings which are plastered upon the body of the pioneer in specialized patriotism and covered over to provide a safe enclosure. Within the enclosure and also underneath the cover there is laid a small piece of felt to allow the mother birds to lay their eggs under conditions which approximate, as nearly as possible, her normal home, but without the usual accompaniment of freedom. Whether the eggs endure the lightning flashes which follow in the interest of research we do not know, but parents as well as bachelors and spinsters (if there be any) and the growing youth of the species are said to succumb immediately.

We hope the anti-vivisection societies will not feel a call to protect the lives of these animals. Indeed, we fear their genial host might refuse to function if the vigorous old ladies who champion the cause of man's fellow beings of the animal world, were to insist that to the host's guests there be given life, liberty and the privilege to pursue happiness. St. Francis of Assisi is said to have referred to cooties as "Little Pearls of Righteousness," put in view of the fact that modern churchmen hold to the relative rather than the specific value of tradition, we are of the opinion that this animal experimentation may be carried on without sin.

* * *

Among the exhibits that attract a crowd by the display of things in motion is that of an automatic sprinkler device for extinguishing fires. Owing to an excess of zeal, however, many of those who stop to look and listen are driven away again. The good people overbid the market, as it were. A large glass chamber is provided which is water-tight and at the top of which is fixed a sprinkler-head. For realistic demonstration of what happens in case of fire an automatic alarm bell is adjusted in the usual manner to the riser so that when a sprinkler begins to operate the alarm is sounded. At intervals, therefore, there comes forth from this gong an infernal, nerve-racking din which is designed to induce any man who enjoys the use of his ears to jump into his clothes. The customary police rules against nakedness prevail at the Palace so that everybody present is clothed. The whang of this fire-gong therefore very nearly, but fortunately not quite, makes everybody jump out of his clothes and take to the windows. To the optimistic temperament there is always occasion for thanks. We rejoice that our booth is not adjoining.

* * *

The Newport Chemical Works, Inc., of Milwaukee, show phenol, of course, for they make not less than 125 tons a day of it, we are informed. They have also an impressive list of coal-tar intermediates of which the following bear the bull's-eye mark: Dinitro-oxy-diphenylamine, ortho anisidine, chromotropic acid, alphanaphthylamine and dianisidine. Guiacol, c.p. in crystals and liquid is offered for pharmaceutical purposes. Then, firmly insisting that Milwaukee is on the map of the United States and probably also because they have a considerable number of intermediates full handy, they have gone into dyes and display a couple of dozen direct, acid and sulphur colors.

* * *

At the exhibition of the Swenson Evaporator Company we were informed that they have just completed a caustic-soda reclaiming outfit for the U. S. Government Explosives Plant C at Nitro, W. Va., of very large capacity. It includes evaporators, disc evaporators, incinerators, leaching battery and other apparatus which required over 30 car-loads for shipment.

* * *

Major Leo F. Goodwin, formerly of the College of the City of New York but now of Canada, was pretty well smashed up by the Huns, but he is still in the ring. As he sat in the booth of CHEMICAL & METALLURGICAL ENGINEERING yesterday, reading our daily issue he suddenly pointed to a line, looked up and asked "Who wrote that?" The line he indicated was that in which we offered free and clear, with no patent rights claimed, the suggestion that telurium dyes might be made to take the place of sulphur colors. The guilty man was present and acknowledged his invention. "Have you ever worked with tellurium compounds?" asked the major. The guilty man admitted that he hadn't. "Well, you never would have put that idea into the minds of aspiring young chemists if you had!" he continued. Then he related from his own bitter experience something of the habits of tellurium, when it starts out in chemical society and begins to make combinations. It displays, he declared, an odoriferous character that reminded him of garlic that had committed suicide. It seems as agreeable and as strong as the mercaptans, and even more enduring. He imagined a beautiful, golden-haired child all arrayed in a pretty new tellurium-blue dress, obviously by a mother with atrophied olfactory organs. And the major, who is fond of children, could imagine no other course of action for the distressed father to pursue than to throw the child out of the window upon the rubbish heap and to make a dash for the North Pole.

Poor tellurium is evidently without friends. We lately reported the indifference of the copper refiners to

it and now comes this learned professor who displays a distinct antagonism.

* * *

The E. I. duPont de Nemours Company shows a great variety of things. Among the novelties is a new rough pyroxyline finish called "crystalac" that may be applied to any hard surface. It is very effective and handsome on glass. They have entered the field in making bronze powder which is displayed in various stages of manufacture. Another thing is dip-colors for electric lights which are applied to finished incandescent bulbs. Artificial limbs are exhibited, made of *papier mache* with a pyroxyline finish. The samples are pink or flesh color, but we have no doubt but that they could easily produce a whole series of chocolate and horse-chestnut hues to meet even the approbation of the art critic of the Chicago *Defender*. Last year they gave away samples of a household cement which this year is going strong without the need of free samples. Under the trade name of "pontoklene" they show a preparation to remove road-tar from automobiles. In the fabrikoid department they have coming along and ready to introduce, but not yet shown, a kind of hospital sheeting that is an improvement on rubber sheets. From the Harrison Works they have of course a great line of paints, and at the dyestuff end are shown about fifty intermediates and some twenty-five direct, basic, acid, chrome and sulphur dyes. This company is engaged in the manufacture of so many different kinds of chemical products that any discussion of the scope of their activities sounds like a poem by Walt Whitman.

* * *

The coal-tar tree is shown in many manisfestations. The National Aniline & Chemical Co. has a large number of bottles arranged in the form of a pyramid with tar at the apex; on the shelf below are the crudes and on the two shelves below this is a comprehensive array of complicated intermediates. Dr. Derrick, the head of the National company's great research laboratory at Buffalo was present as we passed by and we congratulated him on his vast progeny of research. "It was co-operation that made them possible," he replied, "and believe me, some of them were hard to bring up. In fact, some of them were as full of tricks as the wildest boy that ever wanted to shoot Indians."

The National Company conceives the bull's-eye to show that the products have been made in America and by them for the first time from all American materials. They have 169 subjects so marked and very few of them have been made by anybody else in this country before out of German or any other kind of intermediates. Another feature of their show is that nothing is displayed which the company cannot deliver. Some products which are very much desired are on hand in appreciable quantity but they will neither be shown or offered until regular production is established in the works. We were glad to observe one sample of dye and colored yarn of the indanthrene type. That is a good sign. We have been whistling for these colors for a long time.

* * *

The sign of the bull's-eye, which means made in America for the first time since the war began, is differently construed. Some exhibitors hold it to indicate articles made for the first time with all American materials while others construe it to mean that articles so designated have never been made in this country before without reference to the origins of materials. Others again seem to hold that anything which they themselves make and now show as their own product for the first time is entitled to a bull's-eye. And others, having distinct novelties, do not attach it at all. The sign would have more value if there had been made a clearer definition of its purpose; however, bull's-eyes have always been hard to hit at the first shot.

* * *

A guest at the exposiiton who is in a quandary how to produce certain materials fast enough to meet his contracts owing to the labor shortage, said that he would know exactly what to do with 40,000 Turks, which is a question said to be bothering General Allenby at the present time.

* * *

Sometimes we think we know what is going on if we read the journals and the advertisements and go to the meetings of the chemical societies and visit the Chemists' Club, but we make no pretensions to the eagle eye that sees everything. For instance, there's Mr. Floyd J. Metzger who was associate professor of industrial chemistry at Columbia University until a year ago last February. He gave up academic distinction to engage in work for the Air Reduction Co.—the Claude process people who make liquid air and sell oxygen; it is a large concern as everybody knows. It stands to reason that they must have some nitrogen on their hands; lots of nitrogen.

Right there is where Mr. Metzger has been at work and at the Exposition the Air Reduction Co. has a single booth on the third floor. They show a considerable array of synthetic sodium cyanide, made of that boiled nitrogen, and we are told that the technology has been brought up to the theory:

$$NaCN + 2H_2O = NH_3 + HCOONa$$

This reaction has been somewhat of a teaser for a long time, but we are assured that the theoretical yields of ammonia and sodium formate are achieved. Now in addition to the cyanide and formate of sodium there are displayed the following products of their New Jersey works: formic acid and seven formic esters, up to amyl formate; sodium ferrocyanide; aqua ammonia and sulphate, chloride, nitrate and carbonate of ammonium together with *Paris* and Turnbull's blues. The name Paris is given to this otherwise Prussian blue on the ground that, being a synthetic product it lacks the usual livers and lights and consequently deserves a better name. The works are still small but are operating at maximum capacity.

We confess that we feel like apologizing. With nitrogen fixation going on, right across the table, so to speak, and we missing it, we feel we need some of Col. Sellers' Celebrated Eye Wash to quicken our sight. It makes us feel like the boy who went to the Sunday School entertainment and missed the circus. If Mr. Metzger were one of those silent fellows that keeps off in a corner by himself we should not take it so to heart, but he isn't; he is a good mixer.

Recent Developments in Ceramics*

Increased Demand for Silica Brick—Replacement of German Clays—Development of Porcelain and Chemical Stoneware Industries—Success in Optical Glass Manufacture

By A. V. BLEININGER

ONE of the most important functions of the ceramic industries is the supply of refractories for the metallurgical operations of the country, steam power-plants, byproduct coke oven, gas plants, glass works, and many other purposes too numerous to enumerate here. The demand for these products has been enormous and has been met by the refractories industries in a very satisfactory manner. Although at times the need of No. 1 fire-bricks has been greater than the production, such a condition does not exist at the present time, owing to the expansion of this branch of the industry. In many instances the extraordinary demand was caused in part by the unwillingness of consumers to use anything but No. 1 refractories even for purposes where lower-grade products would serve equally well. Fire-bricks of the lower refractory grades are available in abundance, especially since a considerable number of face and building-brick plants have taken up the production of this type of ware. One of the urgent needs in this connection is the establishment of a classification and specification of the several grades of clay refractories. This task is being undertaken at the present time by the War Industries Board. The work of standardizing the shapes of fire-brick has already been accomplished in a satisfactory manner.

Coke Ovens Increase Demand for Silica Brick

The demand for silica bricks has been greatly increased through the development of the byproduct coke oven. Meeting this demand involves not only large quantity production of these refractories, but high quality as well. It is necessary that the transformation of the quartz to cristobaltic be largely completed as indicated by the lowering of the specific gravity to a value of not more than 2.38 and that the product possess good mechanical strength, corresponding to an average modulus of rupture of about 500 pounds per square inch. These requirements are exacting and may not always be met in bricks made from silica rock other than quartzite. Certain materials, like chert and flint, transform to cristobalite more rapidly than quartzite but do not yield as strong a product. Sandstones usually transform more slowly and likewise tend to give inferior strength.

The manufacture of silica refractories is certain to expand still more, both in the eastern states and in the middle west. If the war continues for any considerable period, additional emergency production in connection with the erection of new coke-oven plants will certainly be necessary.

Difficulties have been met in supplying the basic magnesite refractories from the available American materials. This has been due to the nature of our magnesite, which differs from the Austrian ore in being very low in iron oxide and sometimes higher in lime. This makes it necessary to add the iron synthetically, a procedure which adds to the cost of production, since it requires intimate blending and grinding of the mixture and a higher calcination temperature than is needed with the European raw material. In addition the magnesite must be transported across the continent from California or Washington. The latter state produces at the present time large quantities of magnesite quite low in lime and the quality of the material is of a character which is making it possible to reduce operations to a uniform practice.

It has been found possible also to replace magnesite bricks in certain operations by bauxite refractories. The production of magnesia spinal refractories of the composition $MgO.Al_2O_3$ has made a beginning and it is not unlikely that for many purposes it will prove a very desirable material. There has naturally been a shortage of chromite refractories, even though the quantities really needed are small. This has been overcome by the use of thinner partings and in many cases by doing away with this refractory entirely without apparently any serious effects.

Superiority of Ceylon Graphite

Much has been said on the question of graphite crucibles. The graphite problem is undoubtedly the more important one in this connection. It is a difficult matter to replace Ceylon graphite altogether with the domestic mineral. In the first place the greater density of the imported material, 2.25, which imparts to it the characteristic resistance to oxidation, its foliated structure, and the low ash content of the best grades combine to make it extremely satisfactory for the purpose of crucible making. This graphite can be bonded together with a comparatively small amount of clay, since the surface factor per unit weight is smaller than for that of any other kind of graphite.

This point may be illustrated by the volumes occupied by the same weight of several types of graphite. Thus, 100 grams of ground Ceylon graphite after thorough shaking occupies a volume of 90.7 c.c., Canadian graphite 119.6 c.c., and Alabama graphite 152.0 c.c. In other words, it would be impossible to make graphite mixtures of maximum carbon content from the two American materials. Since they offer a much larger surface the amount of clay used must be greater. From this it follows that the ultimate density and thermal conductivity are certain to be lower.

To what extent American flake graphite can be admixed with the Ceylon graphite remains to be seen. The writer has seen mixtures in which the flake added

*By permission of the Director of the Bureau of Standards. Read at the meeting of the American Ceramic Society, New York, September 26, 1918.

amounted to 20 per cent of the total graphite content and gave fair foundry results. It might be possible, however, to perfect processes which will enable the crucible maker to employ larger percentages of domestic graphite, and at the same time secure practically the same results as with Ceylon graphite. On the other hand, there is no reason why a large quantity of domestic graphite should not be used in the making of stoppers and similar articles. The comparison made between the Ceylon and flake graphite is, of course, relative, and refers to crucible value obtained per dollar at the present time. If for some reason this country could no longer obtain Ceylon graphite, the production of metal certainly would not be diminished in any way, as we could get along very well with flake and amphorous graphite, furnace carbon, and coke.

German Clays Successfully Replaced

The lack of the German Klingenberg clay for crucible making is not as serious a matter as has been thought. It has been shown conclusively that it can be replaced both by English and American ball clays.

Similarly, the German Gross Almerode clay used in the making of glass pots has been replaced by American clays and synthetic mixtures in a very satisfactory manner. In fact, it is quite probable that the new techniques now being developed will yield results superior to those formerly obtained with the use of imported clay. The shaking up caused by the war will, in the end, be of distinct service to the glass refractories industry. At the same time, the glass industry will gain in pot service through the realization that the control of the heating up process of the pots in the arches is essential in preventing loss.

Special clay refractories have been developed also with reference to improved thermal insulation, including materials highly refractory, light in weight, and possessed of good insulating qualities. The saving in fuel consumption and weight through the use of such products is bound to be considerable.

Development of Porcelain Industry a National Duty

The manufacture of hard-fire, true porcelain has received a powerful impetus through the war. Three plants are already operating successfully on the production of chemical porcelain, and are making rapid strides with respect to quality. The manufacture on a large scale of hard porcelain tableware is to be begun in the very near future. It is very fortunate that the pioneers in this work have realized the importance of putting their production on a firm basis with reference to foreign competition. By the use of automatic machinery, mechanical dryers and tunnel kilns, they will be enabled to meet foreign competitors on equal terms. The plants now in course of construction excel all European potteries in the elimination of unnecessary labor cost, and expenditure of fuel. The development of a hard-fire porcelain industry is, indeed, a national duty. It would be preposterous and humiliating to contemplate any further dependance on Germany and Austria for these products. By establishing this industry we shall be in position to seek the South American markets to which we have a fair right.

The demand for ordinary tableware at the present time is greater than has ever been known before and difficulty is being experienced in supplying the requirements of the Army and Navy and at the same time those of the country. The simpler shapes such as cups and mugs are now being produced by the one-fire process, which incidentally results in an appreciable saving of fuel.

New Porcelains Show High Electrical Resistance

Porcelains for special purposes have been developed successfully. Thus, the national Bureau of Standards has introduced the manufacture of the refractory Marquardt porcelain, essentially sillimanite, formerly produced by the Royal Porcelain Manufactory at Berlin and used so largely for pyrometer tubes and similar articles. Likewise, we have succeeded in making porcelains possessing remarkably high electrical resistance at elevated temperatures. Several of the bodies produced in the Pittsburgh laboratory of the Bureau of Standards showed a resistance of one megohm per cubic centimeter at 780 deg. C. and at the same time a coefficient of thermal expansion of only 3.81 x 10.6 per deg. C. between the temperature range of 30 to 400 deg. C.

The same materials showed none of the variations in thermal expansion common to most percelains, the coefficient remaining practically constant throughout the range of 30 to 520 deg. C. It is evident that such properties, coupled with good mechanical strength, are essential for such uses as aëroplane spark plugs. There is every reason to believe that the principles thus worked out will greatly assist in producing special grades of electrical porcelain for use under severe conditions. These developments have been assisted greatly through the use of the petrographic microscope in the study of porcelain structures.

Further Developments in Porcelain Expected

The manufacture of electrical porcelain is undergoing improvements at a more rapid rate than ever before in the history of this particular industry. The methods of preparation are more thorough, the details of shaping are being studied more carefully, the drying process is being controlled with greater accuracy, and the methods of testing developed toward more exact differentiation as to quality. The casting process is finding application to an increasing extent. Further developments are to be expected with reference to the composition and firing of electrical porcelain, based on more recent studies on the subject of the function of feldspar as an electrolyte and the volume changes induced by the transformation of quartz to its several crystalline modifications.

Considerable work is being done also with regard to the complete survey of the resources of the country in kaolins and ball clays for use in the ceramic and paper industries, through the agencies of the Association of State Geologists, the Bureau of Mines, the U. S. Geological Survey, the American Ceramic Society, and the Bureau of Standards. It is believed that this survey will enable us to take stock of our resources with the final object of making ourselves independent of any foreign sources. A considerable number of new clay deposits have been located within the past two years, to

say nothing of glass, sand and other ceramic raw materials.

Chemical Stoneware Industry of Vital Importance

One of the clay industries vital in the prosecution of the war is the manufacture of chemical stoneware. The production of this type of ware requires particular skill, owing to the complicated designs, large size and the necessity of the tight fitting of the pieces. But few realize the magnitude of the task which confronted this industry, especially when handicapped by shortage in labor, fuel and other necessities. It is very gratifying, indeed, to be able to say that the stoneware manufacturers have met the situation so well and have been able to supply the needs of the chemical industries. This statement applies equally to the manufacturers of acid-proof, enameled cast-iron and sheet-steel products which have played an important role in recent chemical developments.

Another industry having a direct bearing upon war work is that engaged in the manufacture of abrasives and grinding wheels. The rapid growth of this branch of manufacture and its technical development are characteristic of America. Its work has been done with such quiet efficiency and it has met the demands of the present conditions so promptly that but few realize the magnitude and importance of its accomplishments. Research has played a large part in this development and to the utilization of scientific facts we owe the highly specialized grinding tools made available for large production, as well as for the most delicate processes, such as the grinding of optical lenses.

The industries engaged in the production of ceramic structural materials have naturally been hard hit by the decrease in building activities and by the fuel orders. The manufacturers of building bricks, hollow tiles, sewer pipe, paving bricks, terra cotta, floor and wall tile etc. are endeavoring to hold together their organizations. In districts where war activity prevails the plants are operating to capacity; in others new branches of manufacture have been taken up, such as the production of refractories, crucibles, and certain specialties for war use. But even under such conditions interesting developments are taking place. Much attention is being given to the question of fuel economy through more rapid firing and the utilization of waste heat. New applications of clay are being found such as the use of crushed vesicular vitrified brick material as an aggregate for concrete, having the advantage of light weight, low thermal conductivity, and constancy of volume when heated.

Optical, Signal and Chemical Glassware

With reference to the glass industry the three most interesting developments are those relating to the optical, colored (signal), and the resistant or chemical glasses. When it is realized that at the beginning of the war but little optical glass was being produced in the United States, the rapid development of the art presents an inspiring example. The necessity of war brought together the manufacturers on the one hand and scientific and technical organizations like the Geophysical Laboratory of the Carnegie Institute and the Bureau of Standards on the other.

Although some of the manufacturers had brought their furnace practice to a very satisfactory state it was not realized fully that the raw materials must be practically free from iron, sulphur, chlorine, and other impurities. Likewise, methods for the rapid examination of the glass were lacking so the frequently poor glass was brought to the grinding and polishing rooms of the optical shops; very often, too, good product was by chance rejected. The necessity of temperature measurement and control was not fully realized and the method of stirring had not been brought to a satisfactory development. At the same time the commercial glass pots were the source of much grief due to their high iron content, which discolored the glass in the absence of decolorizers which are not allowable and their failure to resist the corrosive action of the flint and barium glasses. These things have been overcome to a very large extent.

Rapid Progress in Producing Good Glass

Through the use of sand of great purity and constant checking of the composition of the other constituents, the primary difficulties have been removed. The composition of the glasses has been correlated with the optical properties, the index of refraction, the dispersion value, and the light absorption. Time-temperature schedules have been worked out for the melting and cooling periods and satisfactory stirring machines designed. Rapid inspection even of the glass in lump form is now possible by the use of immersion methods and examination with mono-chromatic light in addition to the examination through the polished edges of blocks.

The pot problem has been solved through the use of white burning clays like the kaolins and even more satisfactorily by the production of semi or true porcelain pots. Containers of the latter type are now being made in several works and have proved eminently useful. In fact, it has been possible to melt in such pots dense barium crown glasses which have proved exceedingly destructive to the ordinary types of refractory materials.

Essentials of Optical Glass Manufacture Mastered

The annealing process is being studied by a number of workers, and some interesting information has already been obtained. It might be said then that in the United States we have mastered the essentials of the production of optical glass, and about seven types are being manufactured commercially. Problems dealing with the cutting down of the losses of certain optical phenomena etc., of course, still remain; it is to be expected that continued progress will be made in this art.

It is a source of pleasure to note also the fact that scientific and technical researches dealing with the technology of silicates are being continued at the present time, even though they have more or less bearing upon conditions brought about by the war. We are mastering more and more the control of the class of dispersed systems represented by clays floated in water, their drying behavior, and the changes which they undergo upon vitrification and fusion by resorting to the methods of the scientific investigator.

In this brief survey it has not been possible to empha-

size some of the more important technical advances, nor was it permissible at this time to dwell upon certain developments, such as a new rôle played by clay in chemistry, but it is hoped that this hasty contribution might afford some conception as to the activities in the ceramic industries.

Pittsburgh Laboratory,
Bureau of Standards.

Chemical Glassware

By E. C. Sullivan

MORE chemical glassware is made in this country to-day than was imported before the outbreak of the war, when we depended upon foreign makers for practically our entire supply. The quality is excellent. The Bureau of Standards reports that all of the five brands of American-made beakers and flasks which it tested are equal or superior to the highest grade foreign glass and that one American glass is far superior in the important property of resistance to mechanical shock.

From Table I compiled from the Bureau of Standards report,[1] it is apparent that on an average four of the five brands of American flasks and three of the five brands of American beakers were less soluble than the German in the nine reagents used.

TABLE I—COMPARISON OF FOREIGN AND DOMESTIC GLASSES

	H_2O	NH_3	$(NH_4)_2S$ & NH_4Cl	Acids	Na_2HPO_4	Na_2CO_3	K_2CO_3	NaOH	KOH	Total
Beakers.....	...	...	2	...	5	3	3	5	4	25
Flasks.....	4	4	5	5	4	3	2	5	3	35

(The figures indicate the number of brands of American ware found to be less dissolved in the respective reagents than the brand of imported ware formerly regarded as the best on the market.)

Superiority of American Beakers

The American beaker shows superiority over the foreign in twenty-five cases and equality in four cases (one with water, two with ammonia, one with acid) while the American flask is superior in thirty-five cases and equal in one case (with caustic potash). This difference between the comparative showing of the beaker and that of the flask is almost too great to be accidental and seems to indicate that the foreign flask is more soluble than the foreign beaker.

Another class of laboratory ware, in which resistance to sudden temperature change and to attack of reagents is of less importance and which includes such shapes as desiccators, cylinders, bell-jars etc. has been of slower development in this country but these articles are now being made here in reasonably satisfactory quantity and quality.

Suitable tubing for working before the lamp in the manufacture of such apparatus as cannot be blown or pressed directly in the glass-factory is now produced also, and gratifying progress has been made in the organization of lamp-working[2] establishments for thus manipulating the tubing into the more complicated shapes.

[1] *Technologic Paper* of the Bureau of Standards, No. 107. "Comparative Tests of Chemical Glassware," by Percy H. Walker and F. W. Smith (1918).

[2] In the glass trade the "glass-blower" works molten glass from the melting-pot or tank, blowing it into bottles, beakers, tubing, etc.; as a rule he knows nothing of the fabrication of apparatus from tubing in the flame, which is the function of the "lamp-worker."

Special Glass for Army Medical Department

Referring more specifically to what has been accomplished in chemical glassware since this country entered the war, in the first line would come probably glassware furnished the U. S. Army Medical Department for bacteriological purposes. This glass, which is reported to be of quality far ahead of any ever imported, was absolutely essential in the immunization of the troops against typhoid fever, an immunization the results of which have been record-breaking and for which the U. S. Army Medical Department cannot be given too high credit. Very large quantities of high-grade chemical glass of special shapes have been supplied to ammunition manufacturers also.

In view of the fact that the highest priced American-made beakers and flasks are selling at practically the duty-paid pre-war price of the highest grade imported ware, although the latter has since been advanced in price twice, it may be of interest to consider for a moment in the light of tariff protection the circumstances which led to the establishment of the chemical glassware industry in this country.

At a Tariff Commission hearing on glass held in Pittsburgh in January, 1918, Commisioner W. S. Culdertson remarked, "This case of chemical glassware is an excellent example of a war disturbance. Here is an industry not in existence in this country before the war; the war has raised an artificial barrier against competition from abroad and we have growing up in this country a new industry."

Reasons for Entering the Field

The factors which had weight in determining American manufacturers finally to enter a field from which they had hitherto held aloof were as follows:

1. Sentiment. Undoubtedly patriotic motives and the strong appeal made by chemists and supply houses to glassmakers for relief from the threatening shortage were of some influence.

2. Higher returns. The fact that without foreign competition the full duty-paid price could be asked on all sales, to educational institutions as well as to others.

3. Assured market. There was no slow ousting of the foreign competitor from his established position to face, as would have been the case had the American goods been protected only, for instance, by an extension of the duty to include importations for educational institutions.

If No. 2 was the determining factor it follows that duty-free importation by educational institutions has prevented earlier development of this industry in America. If duty-free importations are 50 per cent of the total and if the tariff is 45 per cent *ad valorem*, then for every dollar saved to the educational institutions about $4.50 of American money has been paid the foreign glass manufacturer which, with a domestic industry developed, would have remained here.

On the other hand, if, as is more likely, No. 3 was the factor of most influence, it follows that a prohibitive barrier, such as interruption of commerce or a very high tariff, may be effective in enabling an industry to get a foothold without causing any increase in price to the consumer.

Corning Glass Works,
Corning, N. Y.

Recent Developments in the Cement Industry

Conversion of a Peace Industry to the Purposes of War—Economies Effected in Fuel and Labor, and Recovery of Potash

By RICHARD K. MEADE

THE cement industry can hardly be said to have profited by the war, although the price of its product is very much higher now than it was several years ago. This increase in price, however, has been met to a large extent by the present high wages paid labor and the cost of fuel and supplies. During the last year, also, the production of cement has been very much curtailed, due to the difficulty of procuring the men, fuel and repair parts necessary to operate the plants at anything like their full capacity.

The cement industry is essentially a peace industry. Its product goes largely to the building trades, for the making of roads and pavements, in municipal improvements, in the development of water powers etc., all of which work has very largely stopped during the past year. As with the metal industries, the output of the mills is now going largely into work of national importance which is approved by the War Industries Board, probably 90 per cent. of the cement shipped today being destined for such use.

The construction work engendered by the war is not of a type in which large quantities of cement are used. The temporary character of the greater portion of this has made the use of concrete unnecessary and the speed with which construction must be pushed has made other building materials more acceptable.

There have been few compensating features to this situation. Both the technical and popular press has given much space to the concrete ship. While most concrete engineers are firm believers in the importance of this type of vessel for emergency purposes, its successful development would not mean any large increase in the use of cement. Any one of several large producers of cement could, by working his plant at full capacity, produce cement enough in one year to duplicate the entire present ship tonnage of the allied nations; and almost any works could produce enough cement in one day's time to build a ship of the size of the "Faith," the first large concrete ship.

Fuel and Labor Largest Items in Cost

In probably none of the great non-metallic industries does fuel play such an important part as in the manufacture of cement. In normal times, the cement mills of the country use between 8,000,000 and 10,000,000 tons of coal; or almost half as much coal is brought into the plant as there is cement carried out of it. The high price of coal and the difficulty of obtaining this have, therefore, been felt very keenly in the cement industry.

The largest item in the manufacture of cement, in spite of the automatic handling of the materials at all stages of the process, is labor. Under ordinary conditions these two items, fuel and labor, make up 80 per cent. of the cost of manufacturing a barrel of cement. The value of the raw materials plays very little part in the cost of manufactures as these consist principally of limestone and shale or clay, which are usually obtained by quarrying from practically inexhaustible sources at the plant itself. Transportation difficulties have also fallen heavily on the cement manufacturer as even a small mill requires from 15 to 20 box cars per day to carry its product away.

Economies in Fuel, Labor and Potash

So much for the business side of the industry. The principal technical developments have been along the line of saving labor and the recovery of potash and heat from the waste gases of the rotary kilns. Improvements, however, owing to the high cost and difficulty of doing construction work, have been confined to only a few plants, and with the vast majority of works the war has made no difference except, as in all other industries, in rendering operation extremely difficult.

Viewed from the chemical standpoint, the most interesting occurrence has been the collection of potash from the waste gases of the rotary kiln. As far back as 1904, the writer, at a meeting of the Association of American Portland Cement Manufacturers, called attention to the fact that approximately half of the potash in the raw materials was volatilized in burning the cement and that the crust which collects on the walls of the kiln stack and has to be removed at intervals contains a considerable percentage of potassium sulphate. No attempts were made to recover the potash from the kiln gases prior to the war, however, and owing to its low percentage of potash I believe that none of the crust was sold for this constituent.

Solving the Dust Nuisance

There has always been objection raised by some of those living near cement mills to the fine dust which is carried out of the kiln stacks and which deposits in the vicinity. While it is extremely doubtful if this dust does any harm to vegetation and certainly is not injurious to health, at the same time it has proved a bone of contention between the cement works and its neighbors. In Southern California particularly, suits brought by the orange growers against the cement plants resulted in injunctions restraining the cement plants from operating without taking care of the dust. The two plants in Southern California, the Riverside Portland Cement Co. at Riverside, and the California Portland Cement Co. at Colton, immediately installed dust-collecting systems. Dr. Cottrell had just worked

out his electrical precipitation method and this was installed at the Riverside plant. The California Portland Cement Co. installed a system of large dry settling chambers followed by washing chambers for treating their gases which was devised by their manager, Mr. T. J. Fleming.

It was soon noticed that the dust recovered by the Cottrell process contained an appreciable amount of potash. No serious attempts were made, however, to sell this dust until the outbreak of the war, when it became a marketable product.

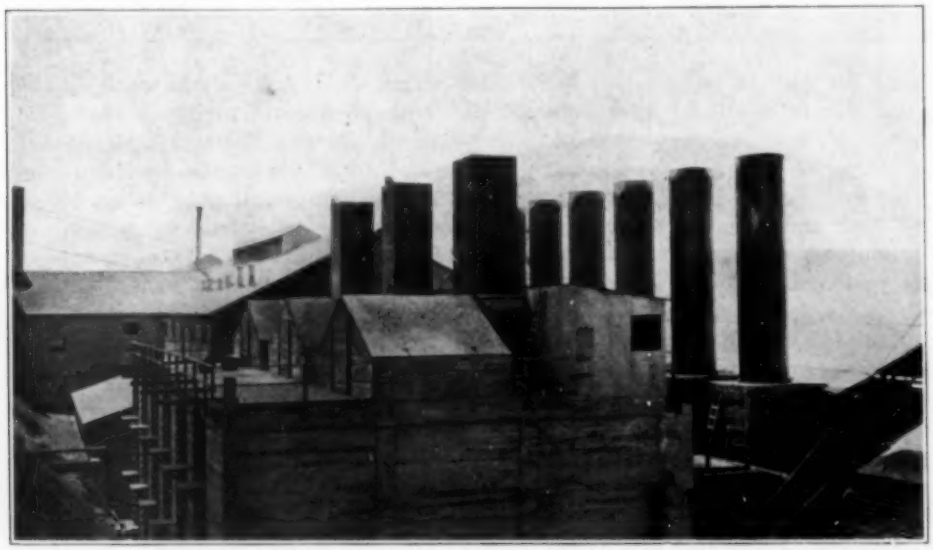

FIG. 1.—POTASH-RECOVERY PLANT, SANTA CRUZ PORTLAND CEMENT CO. (FANS NOT RUNNING)

A little later on, Messrs. Huber and Reath, chemists of the Riverside Portland Cement Co., developed a process for extracting potash salts from this dust. The process is quite fully described in METALLURIGAL & CHEMICAL ENGINEERING of June 15, 1917, and consists briefly in leaching the dust with hot water, separating the solution from the insoluble matter by means of a rotary filter, evaporating the filtrate to the point of saturation and crystallizing the potash out of this in shallow tanks. The product obtained runs from 35 to 40 per cent potash and consists very largely of potassium and sodium sulphate with some sulphur in a lower state of oxidation.

With the outbreak of the war, the crust which collects inside of the kiln stacks became valuable and large quantities of this have been sold by the cement manufacturers in the past three years. The dust runs between 8 and 12 per cent potash. The quantity of the potash so recovered, however, is very small when compared with the total potash liberated in the kiln.

FIRST PLANT PRIMARILY FOR POTASH RECOVERY

The first Portland cement company actually to install apparatus with a view to collecting potash was the Security Cement & Lime Co., Security, Md. Mr. J. J. Porter, manager of this company, was a visitor at the National Exposition of Chemical Industry in the fall of 1915. While there he saw the Cottrell process in operation in a small way and was impressed with the possibilities of collecting potash by this process. He made a trip to the Riverside plant, saw the apparatus there at work, came home and recommended to his directors that they install the apparatus, which they did. This plant has been unusually successful and has been collecting daily from 20 to 25 tons of dust containing from 8 to 15 per cent water-soluble potash, which is sold directly to the fertilizer manufacturers.

When the apparatus was put in operation here, a peculiar thing was noticed, that whereas at Riverside practically all of the potash present in the dust was water-soluble, at Security a considerable portion was not water-soluble. The explanation for this is that at Riverside the kilns are heated with oil while at Security pulverized coal is used, and it is believed that in some manner the potash recombines with the coal ash to form a silicate. This silicate of potash, however, can be dissolved with dilute acid or it can be made soluble by leaching the dust with water under pressure in an autoclave.

By adding salt to the raw materials, the volatilization of potash from these can be very materially increased. Messrs. Huber and Reath recommend and have patented the use of calcium fluoride for a similar purpose. It was also discovered at Security that by the use of salt the recombination of the potash with the coal ash could be lessened to a considerable extent. It has been found, however, that where salt or calcium fluoride is employed the efficiency of the treater is decreased, and that while the volatilization is increased there is a proportionately larger quantity of potash not caught by the treater. In order to collect the potash so lost, a supplementary water-film electrical treater has been developed at the Security plant through which the gases are passed after leaving the dry treater. This is now said to be working satisfactorily.

The Cottrell dry treater, as most chemists know, consists of a large number of sheet-iron tubes through the center of which wires are suspended. These two form the electrodes, the gases passing up through the tube, the dust being deposited on the surface. In the water-film treater, the wires are empoyed but are located between two walls of concrete over the surfaces of which a thin sheet of water is allowed to flow and between which the gases pass. This film of water is a conductor of electricity and acts as does the surface of the tube in the pipe treater. The discharge between the wire and the water-film carries the potash to the latter where the water dissolves it. The same water is circulated over and over again, the solid matter being allowed to settle out; the solution thus gradually builds up in potash. When of the desired concentration it is drawn off, any solids left in suspension are filtered off, the liquor is evaporated, and the potash salts obtained by crystallization.

We have mentioned the precipitation of the dust at the plant of the California Portland Cement Co. by the use of dry settling chambers followed by water

sprays. It was quite natural that the attention of this company should also have been attracted to the possibility of obtaining potash, and a process for such recovery has been worked out by Mr. W. C. Hanna, chief chemist of this company.

Wet Systems of Recovery

In this system, too, the water circulates through the spray system over and over again and gradually gets stronger and stronger in potash. When of the desired strength, a certain portion of this liquor is pumped over into a tank where it is used to leach the dust which collects in the dry chamber. The dust is then separated from the solution by means of an Oliver filter. The former is returned to the kiln and the potash solution is evaporated in open pans. These are located on top the flue leading the hot gases from the kilns to the treater, all of the heat necessary being furnished by the waste gases. As this flue slopes, each pan is set somewhat lower than the preceding one and the liquor to be evaporated flows from the top pan down through the whole series. The potash is shoveled out of the lower pan and is either dried on the casing of one of the fans and placed in sacks for shipment or else sent to storage in the damp state. This plant is now producing between 3000 and 4000 pounds of potash salts per day, containing approximately 40 per cent potash.

The Santa Cruz Portland Cement Co., Devenport, Cal., has installed a system developed by Mr. F. H. Davis, manager, Mr. Fred Davis, superintendent, Mr. L. T. Bachman, chief chemist, and their associates. The collection here is effected by means of water, the distinctive feature of the installation being the use of excelsior beds through which the gases are made to pass after being scrubbed in a tower with water. The gases are first washed in the scrubbing tower by means of sprays and are then passed up through the excelsior beds which are 2 ft. and 6 ft. thick respectively. The solutions flow into a large sump, where solid matter settles, and are recirculated. The mud and liquor are pumped by means of diaphragm pumps to the tank of an Oliver filter, which separates the solids from the liquor. The former is burned to cement and the liquor is evaporated to dryness in a rotary kiln, which happened to be a spare unit in the plant and hence could be utilized for this purpose to advantage. The yield at this plant is about 4 pounds of potash salt per barrel of cement. The salts usually run about 36 per cent potash, principally as sulphate.

Spray Treaters in Utah Plants

Messrs. Huber, Trainor and Fisher of the Riverside Portland Cement Co. have designed a spray treater which they are now installing at two plants, that of the Ogden Portland Cement Co. at Ogden, Utah, and the Utah Portland Cement Co. of Salt Lake City, Utah. This consists of two large brick chambers, the first of which is called the "saturater" and the second the "condenser." Each chamber is divided into four or six compartments by means of brick partition walls so arranged that the gases pass alternately from bottom to top of the large chambers. Sprays are located in the top and the corners of each compartment. In their course, the gases become saturated with water vapor in the "saturater" and then this vapor is condensed in the second or "collecter" chamber. The water is circulated over and over again and the potash collected as at Riverside.

Still another system for collecting the potash is employed by the Southwestern Portland Cement Co. at their plant at Victorville, Cal., which was worked out by Mr. J. G. Dean, chemical engineer of the company.[1]

FIG. 2.—POTASH-RECOVERY APPARATUS, SOUTHWESTERN PORTLAND CEMENT CO.

The wet process of cement manufacture is employed at this plant. The gases issuing from the kiln, carrying from 30 to 40 per cent of water, pass through a condenser where this vapor condenses, probably around the dust and potash particles, and collects with the latter in the condenser tubes. The potash, of course, goes into solution and the dust remains in suspension. The condensed liquor is used as the cooling medium while the hot gases passing through the tubes are made to evaporate this solution. This is brought about by maintaining a vacuum above the latter, so that the apparatus is really a vacuum evaporater in which the kiln gases take the place of the steam ordinarily used. The solutions are concentrated in this evaporator to a density of about 1.1 and the evaporation is finished in an open-top steam evaporator provided with a salt box in which the potash salt collects and from which it is shoveled out when the box is full, allowed to dry in open air, ground and packed.

Two Pounds Potash Volatilized Per Barrel of Cement

The quantity of potash volatilized at the average cement plant amounts to about 2 pounds of potash (K_2O) per barrel of cement; or on the normal output of one hundred million barrels annually, the total volatilized in this country would be about 100,000 tons. Apparatus now available will catch from 60 to 80 per cent of this in water-soluble form. In 1918, 13,582 tons of potash material, equivalent to 1621 tons of K_2O and valued at $700,523, was sold by the cement industry. In 1918 the production probably will be equivalent to

[1] "Wet Process for Extracting Potash from Cement Waste." By J. G. Dean, this journal, Sept. 26, 1918.

about 3500 tons of K_2O valued at one million and a half dollars. When all of the plants now under construction are operating at full capacity the output will be equivalent to 10,000 tons of K_2O annually valued at present prices at about four and a quarter million dollars. There is a possibility of very materially increasing this quantity of potash by substituting for the shale and clay now used as raw materials certain materials of similar composition rich in potash, such as feldspar, sericite, certain shales found in Georgia and other states, leucite etc.

It may be of interest to note that largely through the efforts of Mr. R. C. Haff, chief chemist of the Security Cement & Lime Co., a rapid and very accurate volumetric method for determining potash in cement materials, dust etc. has been worked out. This method is a modification of the cobaltinitrite precipitation followed by titration with permanganate, as used in the laboratories of most of the eastern cement companies and has been found, as now modified, to compare very favorably with the platinic chloride method.

Application of Waste Heat from Kilns

That the heat in the waste gases from the rotary kiln operating on the dry process represents about two-thirds of that supplied by the fuel used to heat the kiln has long been known, and various attempts have been made to utilize this heat in boilers. The first attempts were made at the plant of the Nazareth Cement Co. some twenty years ago and a little later at the plant of the Cayuga Lake Cement Co. Neither of these installations was entirely successful and both attempts were abandoned. Within the last few years, however, efforts to utilize the waste heat in boilers have been successful. The feature which seems to have made these latter installations successful where the earlier ones failed is the fact that the gases were led through the boilers at a fairly high velocity.

The method of using the gases for the generation of steam consists in drawing these through the boiler by means of a fan. The boilers are located as near the end of the kiln as possible and any dust which collects on the boiler tubes is blown off by means of steam.

In the newer installations it is found possible to produce practically all of the power necessary to operate the plant from the kiln gases. It is estimated that the installation of boilers after the kilns at all the cement plants in the country would save approximately one-third of the coal now employed in the cement industry, or about 2,500,000 tons of coal annually. Practically all cement manufacturers realize the vast saving which could be effected by the installation of waste-heat boilers. Unfortunately, however, just at this time it is almost an impossibility to obtain the boilers; moreover, the cost of installation under present conditions is such that the average cement plant does not find it easy to finance the undertaking.

It may be said that the waste-heat boilers and potash precipitation apparatus work very well together, as the flues, dampers, fans etc. for one installation will serve for the other; and since the size of the dust treaters is proportional to the volume of the gases to be cleaned, the boilers will cool and hence reduce the volume of the gases enough to permit of very much smaller treaters being used. Such combined potash and boiler installations are now in operation at the plants of the Dexter Portland Cement Co., Nazareth, Pa., and the Alpha Portland Cemenet Co., Cementon, N. Y.

Baltimore, Md.

The Annealing of Glass*

GLASS has to be annealed to remove any strains set up in it by improper mechanical or thermal treatment, and the presence and development of strains is revealed by passing a beam of polarised light through the glass. Although this optical method of examination has long been applied by physicists and manufacturers of optical glass, it is hardly known to the average glass manufacturer. The Department of Glass Technology of the University of Sheffield has therefore investigated the annealing of glass and the relationship between the composition of a glass and the suitable conditions for its annealing with the special object of facilitating the optical examination and of devising simpler mechanical methods of testing. "Notes on the Annealing of Glass," giving an account of these investigations, were communicated to a recent meeting of the Society of Glass Technology, by Messrs. Solomon English, M.Sc., and W. E. S. Turner, D.Sc.; the latter is in charge of the Department of Glass Technology at Sheffield. Though these notes were only offered as introductory, the detail given are of considerable interest.

Influence of Molecular Strains on Polarized Light

In a polarization apparatus the beam of light, polarized by passing through the first Nicol prism, is stopped by the second Nicol, when the two are crossed. On introducing a cylinder of glass, strained with fair regularity, between the two Nicols, some light will pass and a system of colored rings will be seen, the number of rings increasing with the intensity of the strain. The strain can be removed again by proper annealing of the glass, and the glass manufacturer is mainly interested in three things: the "upper" annealing temperature at which the strain can rapidly be removed without risk of deforming the glass; the "lower" temperature at which the strain can be removed at a slow rate; and the quickest rate of cooling which may safely be used for cooling between the upper and lower temperatures without setting up new strains. For their optical examination, English and Turner use cylinders, 3 cm. in length, with plane polished ends which are placed in a tubular electric furnace. Such a specimen, if severely strained, will show seven rings and the central black cross. As the temperature rises, the rings broaden and seem to chase one another out of the field of view; the number of rings thus diminishes, they become indistinct and vanish, leaving only the black cross, which finally occupies the whole field; that is to say, the field is uniformly dark when all the strain has been removed. In the experiments the times were determined at different temperatures which were wanted both (*a*) for clearing the field of rings and (*b*) for making the field quite dark, and it was observed that a temperature difference of a few degrees in a lehr or other annealing oven made a large difference in the time required. Thus the results were:

*Republished from *Engineering*, Vol. CVI, Aug. 9, 1918.

Temperature, Deg. C.	Time Required (a)	(b)
500	20 .5 hrs.	.....
550	50 min.	Not black after 0.5 hours.
600	20 min.	4 5 hours.
625	.....	18 minutes.
630	.....	10 minutes.

The glass of these experiments was of a fairly high "upper" temperature. In a lead glass, the upper temperature of which was only 450 deg. C., the (*a*) were 35 min., 20 min., and the (*b*) more than 6.5 hours, 130 min., 2 min. at the temperatures of 400 deg., 425 deg., 450 deg. C.

Rapid annealing requires softening of the glass, and it was therefore investigated whether the rate of bending of heated sample rods and the rate of annealing would run parallel with one another. For this purpose a rod of the glass mounted axially in a horizontal tubular furnace, was fixed at the one projecting end, while the other free end played over a vertical scale; the sagging of the free end was measured. The general shapes of these curves proved the assumption just stated, and that glass anneals rapidly when the softening begins. Messrs. Beatson, Clarke and Co., of Rotherham, continued these tests. A test rod, 1 yard long, ¼ in. in diameter, was drawn out from the metal in question, and supported at its center on a brick, which was placed on the pan carrying bottles down the lehr. Arriving at the cool end, the ends of the rod were each found to have sunk by ½ in.; in that case the bottles were found to be strained on examination. When the glass remained in the hot zone for about 15 minutes and was satisfactory, the ends of the rod had sunk by about 3 in.; with prolonged heating at higher temperature the bending became excessive.

Rates of Cooling Vary With Chemical Composition

As regards the rate of cooling, English and Turner find that the cooling rate should neither be uniform throughout the period, nor first be accelerated and then slowed down again, or *vice versa*, but that the glass may, first, *i.e.*, just below the annealing temperature, be cooled rapidly; as the glass stiffens the rate of cooling should be very slow until the glass has become rigid, when the rate may again be accelerated. Thus the rate of cooling should be variable. Three stages would probably prove sufficient. In the first stage, glass of an upper annealing temperature of 585 deg. or 590 deg. C. may be cooled at the rate of 25 deg. per hour down to 500 deg. C.; during the next stage 500 deg. to 400 deg. C., even a slow rate of 9 deg. per hour gave rise to some strains; in the cooling-off stage the rate could once more be raised. Each stage would correspond to a different section of the lehr, and the question is, whether the annealing oven can economically be so constructed as to admit of varying the rates of cooling. When only one variety of glass is made, the mechanical difficulties would not be great; but when glassware of different compositions and different thicknesses are to be annealed together, which is the common practice, the fastest rate of passage will have to be adopted, it is pointed out, even if this rate be that of the slowest glass to be annealed. How much the chemical composition influences these rates is shown by the data of the paper. A glass containing 30 per cent of lead oxide had to be annealed at 450 deg. C.; it could be cooled down to 400 deg. at the rate of 120 deg. per hour, but between 400 deg. and 300 deg. the rate should not exceed 50 deg. per hour, while below 300 deg. the high rate of 300 deg. per hour was permissible. These figures concern a rod 7 mm. in thickness. For electric lamp globes this glass could be cooled at the rate of 12 deg. per hour down to 300 deg. C., and then be allowed to cool off in the open air. Wine glasses could be treated in similar ways. Lime-alkali glasses had to be cooled slowly, at 10 deg. per hour, from 550 deg. down to 320 deg., the further cooling being completed in 3 hours. Boric acid glasses (with 23 per cent of B_2O_3) proved surprisingly difficult to anneal at 570 deg.; as borax acts as flux and diminishes the expansion coefficient of a glass, one might expect ready annealing; but the important factor is the rate at which the viscosity varies throughout the temperate range in which annealing can occur. Chemical glassware containing 64 per cent of silica, 10 per cent of alumina, 7 per cent each of barium and calcium oxides, and 11.5 per cent of soda and potash, proved the most troublesome; between 500 deg. and 400 deg. this glass has to be cooled so slowly that Messrs. English and Turner had so far failed to get an 8-mm. rod through this region without some signs of strain.

The Absent "C" in Germany

One of the peculiarities of the German language is the general absence of the third letter of the alphabet. As the ancient Huns became civilized, put on clothing and began to make a book of words, they thought that they could best teutonize the language of their neighbors across the Rhine by leaving out the "c's." Thus they changed cheese to käse, Cæsar to Kaiser, cement to zement, came to kam, and so on. However, they made one great oversight and forgot to put the "k" in the right place in chemiker. Perhaps some scribe is to blame for this error but the theft could be made no more evident even by the bulging of the tunic.

Why the ancient U-boat navigator's vorvaters had this great aversion for "c" has only recently been discovered. You see the English controlled the seas and hence the German Huns couldn't use them.

Le Chatelier and Bogitch have adapted the Brinell ball test to the measurement of the hardness of bricks, by laying thereon a piece of thin lead foil, 30 mm. square and 0.05 mm. thick, previously blackened by treatment with hydrogen sulphide in a faintly acid solution, dried, and smeared with vaseline, most of which is wiped off again so that a matt surface is produced. The ball polishes the surface of the metal with which it comes in contact and this facilitates accurate measurement of the diameter of the depression. Tests with lead and copper showed that the foil does not interfere with the size of the depression produced. The ball used is 17.5 mm. diameter and is applied for 1 min. under a pressure of 500 kilos. The results are much more concordant than those obtained in determining the crushing strength of bricks. The test is useful in controlling the manufacture of bricks as it will show notable differences in the hardness of different parts of the same brick, due to irregularities in making or burning, or to an insufficient taper in the mould.—*Compt. Rend.*

The Chemical Stoneware Industry and the War

Phenomenal Expansion of the American Industry—American Manufacturer Has Nothing to Learn from Europe—Standardization Desirable for Some Shapes—Domestic Materials Equal to Imported

By PERCY C. KINGSBURY
Chief Engineer, General Ceramics Co., New York City

THE OUTPUT of structural materials and equipment for chemical purposes has naturally received a remarkable stimulus from the phenomenal expansion that has taken place in the chemical and allied industries during the past few years. Obviously the extraordinary progress that has been made in the manufacture of chemical products has been dependent in a very large measure on increased production of the necessary plant and apparatus. It has also been dependent upon the efforts of American manufacturers to furnish equipment which had previously been imported from Europe. The success of most of these efforts is a gratifying tribute to the research departments of our large corporations and scientific institutions, the effect of which in rendering independent our future industrial development is almost impossible to exaggerate.

A result of this wonderful development has been that many minor industries in this country have assumed a position of the most vital importance. Of these the manufacture of chemical stoneware is one of the most remarkable.

Manufacturers were and are still unable to keep up with the sudden increase in demand for their products, this being due to no lack of initiative on their part as will be appreciated when some of the facts concerning this material and its production are taken into consideration.

A parallel condition was found among both groups of the belligerent countries in Europe. It has been intimated in the British technical journals that in England at the outbreak of the war, owing to the lack of suitable chemical stoneware equipment to remove noxious fumes, the workers in munition plants suffered severely in health. France, which depended almost entirely on Germany and Austria for her chemical stoneware requirements, has been obliged to turn over some of her world-famous china and pottery plants to the manufacture of this product.

Germany evidently realized the importance of this industry to the production of war materials. I have been informed that notwithstanding her need for men she exempted from military service the employes of the chemical stoneware plants in the country. She has also made a number of serious but happily abortive attempts to tie up the production of chemical stoneware in this country.

Service Requirements of Chemical Stoneware

Before discussing the advance that has been made in the manufacture of chemical stoneware in this country during the war, let us decide what this ware is intended to comprise.

If the innumerable purposes for which chemical stoneware is used are considered, it is obvious that no one body could possess all the necessary physical and chemical properties required.

This ware covers an entire range of ceramic bodies from the open structure bodies of a firebrick nature, used in the manufacture of vessels subjected to considerable range in temperature, to the dense bodies of a porcelain like nature used for electrolytic work. Within this wire range of products special bodies have to be devised to meet special conditions.

For instance, the low tensile strength of chemical stoneware as compared with metals is somewhat of a handicap that we can only minimize but not entirely overcome by skilful design. It has, therefore, been necessary to prepare mechanically strong bodies for use in the manufacture of such apparatus as acid eggs and impellers for pumps and exhausters that are subjected to considerable tensile stress.

The remarkable results that have been achieved along these lines are indicated by a statement by F. A. Whitaker at the last meeting of the American Institute of Chemical Engineers in which he gave comparative figures of the tensile strengths of English and German stoneware and the bodies that have been developed in this country during the past ten years.

American Manufacturers Equal European

In every other respect also, the exigencies of the war have demonstrated that the American chemical stoneware manufacturer has nothing to learn from the European manufacturer.

At the Chemical Exposition is exhibited one of the largest pieces of stoneware (although not the largest) that has ever been produced in this country. It is doubtful if there are more than two other plants in the world that could manufacture a vessel of this size.

The design of stoneware mechanical appliances and machinery is complicated by the very high shrinkage that takes place during manufacture, which may vary from 8 per cent linear shrinkage or less for some clay bodies, to 16 per cent or more for others. This means that the greatest possible care must be exercised if strains in the finished ware are to be avoided.

In this field we have reason to be well satisfied with the progress that has been made during the war. There is now no stoneware mechanical appliance produced in Europe that cannot and has not been duplicated here. In a number of instances the design has been improved and further progress along these lines is under consideration.

An effort has recently been made in England to standardize such chemical stoneware shapes as is possible. This work was initiated by some of the smaller manufacturers and does not appear to be making much

headway, presumably through lack of encouragement from the larger manufacturers.

Desirability of Standardization in Shapes

That there is urgent need, however, for such standardization, only those who have to cater to the capricious demands of some of the users of this ware can fully appreciate. Taking as a simple example ordinary bell and spigot piping, some users demand a bell only 1½ in. deep while others using the same size pipe under substantially the same conditions insist on a depth of 5½ in. We find the same condition throughout our entire production. This means for the manufacturer the accumulation of an enormous stock of molds and the consequent increase in his overhead expenses, and for the user extra expense and delay which could well be avoided.

In view of the enormous increase in the use of chemical stoneware, particularly in connection with the manufacture of toxic gases and explosives, a review of the useful properties as well as of the limitations of this product may be of value.

The great advantage of chemical stoneware is its resistance to practically all chemicals met with in industrial work. In common with all silicious products, it is acted upon by hydrofluoric acid at all temperatures. It is also acted upon to some extent by phosphoric acid at temperatures above that at which chemical stoneware is ordinarily employed. Strong caustic alkalies, especially when hot, also have action upon it. When the conditions in regard to temperature and strength of solution are not too severe, the life of chemical stoneware when used for alkaline solutions is sufficient to justify the use of the ware for this purpose, but strictly speaking, alkali-proof chemical stoneware is a misnomer.

The Nature and Purpose of the Glaze

There appears to be a popular impression that the acid-proof qualities of chemical stoneware are dependent upon the glazed surface. The glazing should be for the purpose only of adding to the smoothness and appearance of the surface but should not be depended upon to improve the acid-proof qualities of the body. However, as a good deal of nonsense as well as deliberate misrepresentation has appeared on this subject, a few words might not be out of place.

The two methods employed are the application of a prepared glaze by means of a spray or brush, and salt glazing. The prepared glazes may be considered as clay bodies having a lower fusing point than the ware to which they are applied. At the temperature at which the ware begins to vitrify, the glaze melts forming a more or less homogeneous coating over the surface of the stoueware. This is nothing more nor less than a veneer or enamel and has all the disadvantages of enamelled ware in that the slightest scratch or pinhole, or other imperfection will allow the acid to penetrate to the surface beneath; and if the body is not properly vitrified and thoroughly acid-proof the action of the acid will ultimately result in the peeling off of the glaze. Crazing or cracking of this glazed surface is a natural and obvious result of subjecting such ware to changes in temperature.

Salt glazing is carried out by throwing common salt into the fire as the maximum temperature of firing is reached. The salt volatilizes and the vapor reaches every part of the kiln where it is decomposed, the salt forming a double silicate with the alumina and other bases in the clay body, while dense fumes of hydrochloric acid gas pass up the chimney. A salt glaze is, therefore, a true glass intermolecularly combined with the body and one, therefore, which cannot craze nor peel. Moreover, as a salt glaze will not form on a surface that is imperfectly vitrified, this form of glaze is guarantee of the proper vitrification of the body.

Domestic Materials Equal to Imported

The idea, carefully fostered by those interested, of the superiority of imported raw materials, has been exploded in so far as it relates to the manufacture of chemical stoneware.

There was a time when we (I refer to the company with which I am associated) imported about 80 per cent of our clays. This was partly because they were cheaper than clays of equal quality of domestic origin, and partly because it was a good selling point, many of our clients being hypnotized by the popular bugaboo of the superiority of imported over domestic products. The imported raw materials we now employ are only a very small fraction of our entire consumption and are used only for a few special purposes. Domestic clays suitable for the manufacture of chemical stoneware are, however, not very widely distributed. Although our plants are situated in one of the greatest clay formations in this country, we can use comparatively little of the raw materials that are right at our door.

The expense of a long haul is, however, a great inducement to some other manufacturers to utilize local clays without due regard to their entire suitability. One of the difficulties thereby experienced is due to too short an interval between the temperature of vitrification and the softening point of the clay body. Thus the manufacturer using such clays who wishes to avoid deformation as much as possible, must be satisfied with incomplete vitrification, an attempt to improve the acid-proof qualities of his product by means of a heavily applied glaze. On the other hand, if he pays more attention to the proper vitrification of his product he cannot well avoid the distortion of the ware during firing.

High Degree of Skill Required in the Industry

The present exhibition should do much to remove the prevalent idea that the manufacture of chemical stoneware as regards the necessary technical ability and skill is on a par with the manufacture of other clay products such as brick and tile. As a matter of fact the manufacture of this ware calls for a degree of specialized experience and painstaking skill exceeded by few other industries. This experience has in many cases been handed down from generation to generation; there are employed at the plants of our company a number of men whose forefathers worked at the first chemical stoneware plant in existence.

This is one important reason why it has been difficult to meet the demands of the chemical and explosives industry at the present time. This demand induced manufacturers of other ceramic products such as sewer pipe, brick and tile, fireclay, terra-cotta and hollow tile to enter the field. The efforts to adapt such plants which

are designed and equipped for the quantity production of a few simple shapes to a specialized industry such as this were foredoomed to failure, and this factor ultimately placed a still further strain on the few plants that possessed the necessary equipment, skilled labor and experience.

Moreover the entrance of such manufacturers into this field without the necessary experience and skilled help has undoubtedly done some harm to the industry as a whole, if such ware as they are able to turn out has been taken as a criterion of American chemical stoneware. There is little doubt, however, that the end of the war will also see the end of these peripatetic chemical stoneware manufacturers and that the industry will undoubtedly benefit from the demands that are being made upon it at the present time.

Development of the Stoneware Industry

FIFTY-THREE years ago when the United States Stoneware Company was incorporated, the stoneware business was confined to the manufacture of crocks and jugs, and the maximum size it was thought possible to produce was a vessel of ten gallons capacity. Thirty years ago, however, this company conceived the idea that larger vessels could be made successfully and at once commenced experimenting. The result, through the aid of new methods, was a thirty-gallon crock. The demand for this vessel became so great for preserving meat, fruit, vegetables, butter, eggs etc. that its use became almost unlimited.

At this period the manufacturing of chemicals and explosives in the United States was in its infancy and the demand for acid-proof stoneware was correspondingly small. However, it was found necessary to increase the capacity of stoneware vessels to a still greater degree, the result being that to-day acid-proof stoneware is made to meet the requirements of customers in almost any desired form and size.

It may not be out of place to relate an incident that occurred back in the early 70's when Horace Greeley, the talented editor of the *New York Tribune* was the speaker at the exercises of laying the corner stone of Buchtel College in Akron, Ohio.

He ventured his conception of the process of making a stoneware jug: that a rope of suitable size was coiled in the form of a jug upon which clay was plastered, of desired thickness, and at the proper stage of dryness the rope was removed by drawing it out through the nozzle of the jug, being then ready for the kiln. A little later in the factory, however, he saw a jug maker standing on one foot and manipulating a pedal with the other, which caused a horizontal disk to revolve on which he was working a lump of clay with his hands through different stages until it became a finished jug ready for the kiln. He very amusingly admitted that the process of making a jug and his previous conception of it were much at variance. Thus verifying the fact that however wise one may be there is still more to be learned.

The process of making jugs and all other stoneware, to-day, is far in advance of that which was in vogue at the time above mentioned. Demand made it necessary to speed up, and processes employed now produce five times as much stoneware in a given time. Perhaps no greater advance has been made than in the improvement of glazes.

Twenty years ago the U. S. Stoneware Co. became convinced that the cheap and ancient method of salt glazing which serves to cover up defects could be replaced with a glaze which would enter into and become a component part of the body of the clay. Thus began scientific experimenting which resulted in an exclusive glaze which displaces the antiquated salt glaze, the latter being the result of a few shovels of low-grade salt placed in the fire holes of the kiln which, at the point of burning off, fuses over the surface of the ware. ware.

On the other hand the special glaze is applied to the ware in its partially dried state before firing and thus becomes a component part of the body of the ware. It is obvious that this system of integral, as well as a surface glaze, is far superior to a thin coating of salt glaze only.

We feel reluctant in mentioning the cruel war that the Kaiser has forced upon us and yet did we not condemn the atrocious military power of Germany which is striving to usurp the rights of the remainder of the world we should be lax in a duty which is incumbent on every patriot of the United States.

The impetus which the Kaiser's war has created in the many lines of business is recoiling upon him with tremendous force and will end in his defeat not only through force of arms but commercially as well. The slogan "made in Germany" has lost its effectiveness. Uncle Sam has awakened to the fact that he, too, can accomplish the difficult task of producing the numerous articles of commerce which formerly were an asset for Germany. The great resources of this republic protected as it must be by wise statesmanship will build up our industries and the United States will be known as the foremost nation of the world.

In meeting the requirements of the war the United States has certainly accomplished wonderful results. In every line the speeding-up process is going on to an extent that under other conditions would have been thought impossible. This connected effort to produce is perhaps no less pronounced in the line of chemical stoneware than in other important lines. The U. S. Stoneware Company has found it necessary to increase its capacity ten-fold that of normal times. When we have conquered the Kaiser, however, this condition may be changed to a certain extent, although the advances made in nearly every line of manufacturing which formerly went to Germany will be an asset for the United States.

Direct Etchings On Glass

Diamond scratches are usually preferable to the usual wax and hydrofluoric acid etches because of being direct; however, by applying sodium fluoride in gum arabic paste to the glass surface, a platinum wire anode connected in electric circuit with the moist paste coating will liberate free hydrofluoric acid at the point of contact. With such an arrangement permanent and substantial marks can be directly placed on the glass. The cathode can be attached to a strip of cloth which the paste will cause to adhere to the glass.

Home Made Optical Glass

The American Industry May be Epitomized by Saying that It Has Grown from Nothing in 1914 to an Export Business in 1918

BY H. E. HOWE

SO SPECIALIZED has glass production become that window, plate, colored, heat-resisting, chemical, moulded, automatically-blown and optical glass each require their own organization for successful manufacture, and the trade merchandizing each ware is seldom fully familiar with other kinds of glass. The ultimate consumer, including the average chemist, has some difficulty in appreciating the differences.

Chemists are familiar, to be sure, with the research required to furnish glass having the peculiar characteristics of chemical glassware. But what of optical glass? In order that what has been accomplished in America in the past four years may be more fully appreciated, it will be useful to review something of the past one hundred years in optical glass.

Prior to 1870 there were but three notable exceptions to the general apathy in devising new types of optical glass. These were Fraunhofer, who had partial success but who failed to produce anything commercially and whose formulae were lost; an English committee headed by Micheal Faraday in 1825; and an English clergyman, Harcourt. Although the report submitted by Faraday in 1829 was of small practical value, it did have important directive influence. Harcourt was handicapped through lack of guidance to be had only from the spectrometer which was not available because his meltings were too small, but he recorded much of value and was one of the very first to experiment with new elements. We may say, therefore, that until Abbe's appeal in the late 70's, the impetus to improvement in optical glass may be credited largely to the Anglo-Saxons.

The efforts put forth by the glass makers concerned diminishing the color, increasing clearness and homogeneity in well-known crown glass and in obtaining greater refractive power and dispersion in flint than had been customary, but no one cared to experiment with new elements and compounds against which there was much prejudice. Crown glass was composed of potassium carbonate, with perhaps some sodium carbonate, lime and silicic acid. Flint contained no lime, substituting lead oxide therefor. Of course, many variations in amounts were used but there is no evidence that, excepting in an experimental way, any other elements than those named had been employed.

Abbe's appeal was from a scientific viewpoint, and without discussing the commercial aspect he emphasized the need of new materials with which to construct new microscopes etc. to be used in furthering scientific progress. Manufacturers were then, as today, reluctant to spend money on research without advanced guaranteed profit, and in this case there was no promise of large returns even if successful. It was fortunate, therefore, that Schott, the son of a glassmaker, was attracted by the appeal and that the research work had the financial aid of the Prussian Bureau of Education and the Prussian Diet.

Until this work began, Germany was no better than second in optical glass production, France being the leader. But as in so many other instances, concentration with scientific method and ample finances was to lead to success.

Limitations of Optical Glass

It will be helpful here to mention some of the factors in the problem and then a little of what was undertaken under the name of the Jena Glass Laboratory. The glass flux must not act upon the material of the pot or crucible and in this manner absorb impurities. Elements which evaporate during the melt have a tendency to produce veins and so must not be used. These so-called veins or striæ or cords, as they are variously known, are of no consequence in many kinds of glass, but optical glass must be free from them and the slightest indication of them results in the glass being discarded. Large bubbles must be avoided, and all bubbles as far as possible, while for telescopes, microscopes, binoculars, eyeglass lenses and wherever the light is to be transmitted to the eye, no bubbles can be tolerated. Cloudiness, crystallization and any liability toward devitrification in the process of melting, cooling and subsequent re-heating must be avoided. The glass must be such that no stress will be produced when it is brought from the plastic to the solid state and it must not be hygroscopic or tarnishable in ordinary atmosphere. Optical glass must be as colorless as possible, although other characteristics are at times so desirable that color becomes a secondary consideration, as in special flints. Besides all these limitations, the product must have strength enough to bear the manipulation necessary in grinding, polishing, mounting etc.

Furthermore, refractive index, dispersion, absorption of light and density are values which should be maintained as constant as possible in successive melts of the same composition, for it is largely upon these values that the optician makes his choice and calculates his lens elements accordingly. For some optics it becomes necessary to refigure formulae for slight changes in these values between different melts and even to reconstruct grinding and polishing tools.

Early Experimental Work

When Schott and Abbe began their work, silicic acid was the only glass-making acid oxide in use. There was a tradition that boric, phosphoric and arsenic acid gave tarnishable glasses and, with the exception of Harcourt, no one had done much to determine the in-

fluence of the different metallic oxides upon the physical constants of optical glass. The first experiments were along this line and had to be empirical. They included the use of all the glass-making acid oxides with the oxides of boron, phosphorus, lithium, magnesium, zinc, cadmium, barium, strontium, aluminium, beryllium, iron, manganese, cerium, erbium, silver, mercury, thallium, bismuth, antimony, arsenic, molybdenum, niobium, tungsten, tin, titanium, uranium and fluorine.

The meltings were just large enough to yield pieces for specrometric and refractive measurements and were made in porcelain, fine clay and platinum. The elements were introduced gradually in quantities of at least ten per cent and many were eliminated very early on account of rarity, volatility or coloring influence. It soon began to be demonstrated that the hitherto fixed relation between refraction and dispersion could be varied and that both ends of the spectrum could be lengthened.

The problem of new compositions was accompanied by that of providing suitable melting pots, technique in stirring and heating and in annealing to eliminate stresses. Special clays, "ripened" and carefully blended, make the final type of pot which required eight to ten months from the time it was laid down until ready for the furnace. After a great many trials and tests with polarized light, fine annealing was developed. It was determined that the temperature of solidification lay between 370 and 465 deg. C. and that by spreading the fall of 95 deg. over an interval of four or more weeks perfect results could be obtained. Accordingly, ovens were built with thermo-regulators and devices whereby they could be maintained at any point between 350 and 477 deg. C. and allowed to cool with any desired slowness.

Nineteen Glasses Developed up to 1886

Up to 1886 the net result of all this tedious work was nineteen glasses of essentially new optical properties. These may be roughly divided into four groups, flint containing boric acid, borosilicate crown, dense barium crown and phosphate glasses.

Flints containing boric acid are not so durable as the older types, but with them it is possible to make three lens objectives free from the secondary spectrum. The borosilicate crowns are important and find use in small objectives, prisms etc. They are of lower refractive index and dispersion than the ordinary crown glasses.

Dense barium crown glass contains barium and boric acid and is used in practically all anastigmat photographic lenses, but in order to obtain the necessary optical qualities it becomes necessary to approach very near to chemical instability, and this leads to difficulties in manufacture. The phosphate glasses proved unstable and subject to deterioration in use.

Since it would be an advantage if it were possible to compound a glass that would have certain calculated characteristics, efforts have been made to determine whether the characteristic of metallic oxides are persistent to the same degree in glass. Density, tenacity or tensile strength, resistance to crushing, elasticity, hardness, specific heat, conductivity of heat, cubical expansion, thermal endurance and chemical behavior have been carefully studied. In each instance the properties have been determined from observations on properly selected glasses, and from the data thus obtained values have been assigned to the oxides. Other glasses have then been compounded with relation to these values and the results then compared with what had been expected from the calculations. Unfortunately, in practice the plan does not work out very well, although computed results differ in some cases from those observed by no more than 1½ per cent. The maximum difference, however, occasionally runs above 40 per cent.

Relative Influence of Elements on Glass

The elements having the greatest influence on the density of glass are barium and boron, while sodium and arsenic have the least influence. Calcium appears to have the greatest bearing on tenacity, and magnesium the least. Aluminium is responsible for the greatest hardness and calcium for the least. Auerbach fills the large gaps in the middle parts of the Mohs scale of hardness by inserting a crown glass between quartz and feldspar and two flints between apatite and fluorspar. With these additions the scale in ascending order is gypsum, rock salt, calcspar, fluorspar, two flint glasses, apatite, feldspar, crown glass, quartz, topaz and corundum.

Silicon has the greatest influence on resistance of glass to crushing, and potassium the least. Magnesium oxide appears to impart the greatest elasticity to glass, and zinc the least.

To determine the thermal endurance, polished cubes are heated to ascertain the greatest difference in temperature they can stand without cracking. Some glass can withstand a sudden rise in temperature far better than a sudden lowering of temperature, and the more the difference exceeds that temperature which can just be borne, the greater are the number of cracks produced. One glass, which in testing could withstand a difference in cooling of but 52.8 deg. C., was able to withstand a sudden elevation of 465 deg. C.

Glass a Solid Solution

Glass is undoubtedly a solid solution in which silicic acid or other acid-forming oxide is the solvent. This accounts for much of the behavior of glass, such as the lack of homogeneity in optical glass. This improves as the glass ages, and since a readjustment of the molecules is rendered much more difficult in glass than in a liquid solution, a comparatively long time is required for the proper aging of optical glass. When this aging does not accomplish sufficient homogeneity, the optician produces an optically plane surface by means of local corrections obtained by hand polishing and frequent testing of the results thus secured.

The production of these new glasses to which others have since been added was taken up by Schott and Genossen with much success, stimulated by the demand for many new optical instruments made possible with the glass. It was thus that Germany soon became the world center not only for such glass but for all classes of optical instruments as well.

The French and English factories devoted their attention to specialties or, lacking an advertising bureau equal in efficiency to the German, made equal glass unknown except to old customers. It would be

worth knowing whether back in the 70's the Prussians had military optics in mind when their government helped to finance Abbe and Schott in their experiments!

Military Demand for Optical Glass

When 1914 came, ordnance had been developed to a point such that whereas in our Spanish war 5000 yards had been considered a maximum range, we must now have range finders capable of reading accurately to 20,000 yards if they are to be efficient, and this necessitates high-grade optical glass in quantity to keep pace with the requirements of modern sized armies.

For some time, a few men had thought of producing optical glass in America. The glass companies could see no reason to finance the necessary expensive experiments unaided by the consumer, especially when the annual requirements were relatively small and no market was actually assured. Those using such glass were satisfied with their source of supply and consequently the little work that had been done was unsupported and half-hearted. Even after the war began, those vitally concerned retarded developmental work, sfrong in the belief that the war would be but a matter of weeks and the old source of supply soon again available.

Then came the demands of the Entente for range finders and binoculars beyond the capacity of their own or American optical works. Glass stocks melted away. The British Advisory Council recognized both chemical and optical glass manufacture as key industries and plunged into research and technical experiments. We began to realize that the best optics, even in our own military establishment, were made with Jena glass; that no more of that glass was forthcoming and that if business, our only consideration at that time, was to continue, we must make glass.

Fortunately, in the writer's opinion, there was in America a Belgian who had come here years before hoping to engage in the manufacture of optical glass. He was a technical man, and after making plate glass here in the absence of interest in American optical glass, he had returned to his ideal and was conducting some experiments in 1914. Engineers were called in, a larger plant provided and, inadequately assisted, this man began the commercial scale production of optical glass in America.

Obstacles To Be Overcome

If error and failures were not to be expected, then the magnitude of the difficulties to be overcome has not been set forth with sufficient clearness. True, the work that had gone before was of immeasurable value and the new starting point well advanced, but formulae had never been published and were considered part of the stock in trade by European glass makers; a chemical analysis of such a complex silicate can do little more than furnish guidance in making up a melt. It seemed to require an unduly long time for the necessity of pure raw materials to become impressed upon the minds of those engaged in the work, whereas the very nature of the product requires careful control in this regard as had been made a point of importance by those propagandists interested in convincing America that optical glass was altogether too difficult a product to be attempted here. Sands thought to be of exceptional purity by the usual glass maker were found to contain sufficient iron to condemn them for optical glass where freedom from color is a requirement and no decolorizers such as manganese can be permitted. Lead oxide for flint glass must be of high purity and quite free from metallic lead, and so with item after item there are substances very likely to be present which can not be tolerated.

And pots! One of the large problems of the entire glass industry involving the study of clays which one well-known ceramic engineer says no one knows much about, least of all chemists. A large number of pots are required, for the usual practice is to allow the melt to cool in the pot which is thereby destroyed either during cooling or in breaking up and sorting the glass. Pots are of two types and are about 40 inches in diameter and height, though smaller ones are frequently used. The open pot is used for those melts not subject to the action of the products of combustion, while the closed or "monkey" pot affords almost complete protection, the only opening protruding at the side. Many pots have been made and used in less time than nas ever been thought possible, and there have also been delays due to the breaking of these green pots in the melting arches.

Then there have been temperature problems, troubles with refractory brick and cement in the furnaces and all those factors which enter into the use of high temperatures under control. One of the tricks of the trade is the proper stirring of the melt. A water-cooled, fire clay stirrer is employed and this must travel in ever changing circles propelled by hand or power through a mechanical device. The European practice leans strongly toward hand-stirring because of the care required not to approach the pot walls too closely, thus bringing into the melt traces of the dissolved clay, and to vary the manipulation in accordance with changing conditions within the pot. Properly supervised mechanical stirring has given good results however.

Review of Progress

What has been the progress under the stimulation of necessity in rapidly providing a key industry? The Bureau of Standards took up a portion of the burden, various glass makers began serious work, and through the solicitation of the members of the Naval Advisory Board, the Geophysical Laboratory of the Carnegie Institute applied its very considerable resources to the assistance of those already engaged in commercial scale experiments. America began to overcome her shortage of optical glass. There were and still are many problems. Some difficulty has been experienced in bringing glass makers of the old school to realize the exactness of the new requirements. "It is only a small bubble," but you can not have it in an eyepiece. "Just a single string," yet the presence of any striæ in a prism renders it unfit for range finder or binocular.

Prices have gone up and up, but not out of proportion to advances in cost of labor, fuel, raw materials and other items of production. For some grades of glass 20 per cent usable is considered a good yield, though this is materially increased in most instances. Output has been concentrated on glass used for military instruments and eye glasses and at the time this is

written America is in a position to satisfy her own requirements, to help her Allies and to export optical glass! One plant as early as February of this year produced more than sixty tons in one month; moreover, as many as six plants, great and small, are now at work, although some are not making much of a profit as yet, for the expense is heavy, the output small and the field restricted.

Other varieties of glass for microscope and photographic lenses will be added later, but meanwhile we are exploring new fields. One manufacturer has perfected methods for casting some optical glass very much as plate glass is poured on large casting tables and rolled out before annealing in a large sheet. This sheet or plate is then ground and polished, defects cut out and the remainder cut to size for final inspection. This has several advantages over breaking the glass to weighed portions and moulding these to size and shape or even sawing, notwithstanding the large loss in the grinding and polishing operation, amounting as it does to about 50 per cent of the melt.

The Bureau of Standards has undertaken research on glass pots with special reference to increasing the life of pots. Small-scale work with porcelain has yielded results which look promising.

From nothing in 1914 to ability to export in 1918 is a brief way of expressing what has been done. The key industry has learned to walk and we shall be able to make military optics to help us reach the Hun no matter how far he may run. This is the open season for German monopolies and they are being broken even as a good marksman shatters clay pigeons.

Cambridge, Mass.

The Manufacture of Beakers

The question as to the thickness of the beakers and flasks has been the subject of careful consideration. Bohemian ware was always very thin, as the glass from which it was made was not resistant to heat. With resistance glasses it is possible to make beakers and flasks very much heavier than the Bohemian ware, and in this respect we, and the American manufacturers, have followed the practice of the makers of the Jena glassware. A 500-c.c. beaker should be about 0.8 mm. thick, and a 1000-c.c. beaker 1.0 to 1.2 mm. thick, but the articles must, of course, be evenly blown. Such articles as graduating flasks and X-ray bulbs must be blown exact to weight.

When a beaker is blown, it resembles a bottle, and the next stage in the process is to cut it to the proper height. The article is slightly scratched with a diamond, and placed on a revolving table, while a fine blowpipe jet plays upon it at the height of the scratch. If the goods are well annealed, and evenly blown, they crack off quickly and evenly, provided that the jet is properly adjusted. Badly annealed goods and badly blown goods crack off so as to leave jagged edges. Thus the efficiency of production depends very largely upon efficient first annealing.

The flanging and lipping of beakers, and the flanging of flasks, are operations which are carried out entirely by machines operated by girls. The designing of these machines did not call for a vast amount of ingenuity, but in perfecting the details it was necessary to study the processes very closely in the works.—*Jr. Soc. Chem. Ind.*

Industrial Glassware

By S. R. Scholes

AMONG the lines of manufacture in America that have been greatly stimulated by conditions arising out of the great war is that of glass for industrial purposes. We imported most of this glassware before the war closed the European sources of supply. Perhaps the chief reason for that dependence upon Europe was the low tonnage estimated in making such ware. We were accustomed to producing tons of steel, while we imported cutlery. Similarly, we produced great quantities of plate and window glass, bottles, packers' goods, lighting glassware, tableware, even fine blown and cut glassware, because the demand was great and the tendency toward large-scale production, involving machines, could have full swing; but we imported scientific and industrial glassware, largely because we regarded the business as too small for consideration.

Another reason for hesitancy in entering competition with European workers lay in the fact that a large part of the scientific glassware came into this country duty-free, and therefore it was practically impossible for us to produce it, on account of the higher wages paid American workmen. Since the character of the glass itself which entered into scientific utensils and instruments was much the same as that required in the industries, this had a direct bearing on the production of industrial glass.

Strong Demand at Good Prices

An abrupt change took place when the war began in 1914. Not only were importations stopped, but also foreign competition. American manufacturers were both obliged to meet a new demand and allowed to obtain prices which warranted them in doing the necessary development work. Further incentive came from the expansion of chemical industry. New processes and enlarged plants required special pieces of glass apparatus and parts, and larger quantities of standard articles. The same effect was produced by the general expansion of the industries in 1915 and 1916. More steam boilers meant more gage glasses, more motors and machines, more oil-cups. When America entered the war, still further stimulation along special lines, especially optical glass, was manifest. The result has been that this country is rapidly approaching independence in the matter of glass for industrial purposes—if indeed that is not already attained.

However, the manufacturers did not at once grasp the situation to their full advantage. The wave of prosperity that began in 1915 brought a greater demand for glassware for household use, and factories whose equipment would have enabled them to produce large quantities of glassware for technical use declined at first to enter the field. They were busy enough as it was. In those days, few realized the length of war-time ahead, and peace seemed always only a matter of a few months. Therefore, it was argued, why waste money preparing for a business that could only be transient? But the demands of industry for glass became more insistent, and, with the curious reluctance toward the new and unfamiliar that has always seemed to characterize the makers of glass, they were supplied.

Discussion of the varieties and properties of indus-

trial glass in this article may well leave out optical glass, for that exceedingly important field has been well covered by the men who have so ably risen to the emergency and brought out with speed and thoroughness the vitally necessary glass, without which our best ships and guns would have been as futile as the blind. If ever in the future government appropriations for the bureaus engaged in purely scientific research should be grudged, their supporters need only point to 1917 and optical glass!

Physical Requirements and Compositions of Glass

Glass for many, if not most, of its industrial uses requires exceptional strength, a low coefficient of expansion, and resistance to the attack of solvents of all sorts. It must be thoroughly annealed, for a residuum of internal strain that would be harmless in a window pane of a piece of table glassware, might be fatal in a gage-glass or a sight-feed tube. The articles themselves must be made to an accuracy of dimension approaching that of machine parts, a condition very unusual in ordinary glass articles.

The composition of glass to meet the requirements outlined is comparatively simple, although quite different from ordinary glass, such as would be found in bottles, for example. It is an old practice in this country to make a heat-resisting glass out of sand and borax. Such a glass is a sodium boro-silicate, and may be considered the foundation or type of heat-resisting glasses in general. The boric oxide serves a two-fold purpose: It replaces the alkali to some extent—the alkali is the constituent of glass having the greatest coefficient of expansion; boric oxide itself has the lowest. Another fortunate fact, is the reduced solubility or increased resistance to water and chemical reagents of the borosilicates compared with the simple silicates.

The improvement of this sodium boro-silicate glass was the main problem to be solved. If pure fused silicate could be worked at a reasonable temperature, it would represent very nearly the ideal glass for industrial use. The more nearly its properties, except, of course, its softening temperature, are approached by any glass, so much the better for its durability. Therefore, the best heat-resisting glasses contain high percentages of silica, sometimes as high as 80 per cent. This makes them rather hard to melt and to work, but this very fact increases their utility for many purposes. In order further to decrease the solubility of these glasses—a very important matter in the case of gage-glasses, for example—it has been found advisable to add certain of the insoluble bases, such as alumina, zinc oxide, and magnesia.

The results reached in American factories are several closely similar heat-resisting glasses which are also very stable and resistant toward water and reagents of all sorts and toward high-pressure steam. So far as glass compositions go, American wares are now highly satisfactory. They are superior, in some lines, to the best that were ever imported.

Annealing is a matter that now receives more attention than formerly, for many failures of glass articles can be laid to the internal strain left by insufficient annealing. This, as everyone knows, must be removed by heating the ware to the initial softening point of the glass, then cooling it so slowly that both interior and surface portions of each piece reach the rigid condition at virtually the same time. With the devices now obtainable, which make use of polarized light for detecting strain, glassware can be examined before it is sold, thus eliminating one source of loss and disappointment to both maker and user.

Accuracy of size and uniformity of thickness in glass articles require painstaking skill on the part of moldmakers and glassworkers. The developments here are also gratifying. When they have become convinced of this necessity, American workmen have taken a live interest in methods of manipulation to secure it, and have shown that there is little reason left to mourn the lack of imported ware for its workmanship.

Tariff Necessary to Offset Our Labor Costs

There are no statistics available, but it is certain that the volume of business in glass for industrial uses is very large. It is also growing. The producton of heat-resisting glass that will stand sudden and extreme changes in temperature has been folowed by new applications for such glass. Many pieces coming under the general head of "sight-feeds" are being made, enabling the operators to see and thus control many processes hitherto "in the dark." Now and again a use is proposed which no glass can be expected to fill. On the other hand, glass parts could undoubtedly be introduced in many places in large scale chemical apparatus, where visibility is desirable but not now possible.

Summarizing the effect of the past four years on this phase of the glass industry, American manufacturers have proven themselves capable of supplying their country's needs, and have even gone farther and created new and better glasses than are made in Europe. A list of the varieties of glassware now made here that were not made to any extent in this country before the war, is given in the recent report of the Tariff Commission on "The Glass Industry as Affected by the War": Optical glass, laboratory or chemical ware, glass gage tubing, watch crystals, glazing glass, oven glass, glass brick, siphon bottles, photographic glass, and high grade picture glass and glass for spectacles.

This is an expansion worthy of note, and it has come in no sudden or spasmodic manner. It rests on a good foundation of careful study and work. The question of competition with Europe in industrial glass after the war will depend only upon price, for the quality of ware is assured. There must be, it is evident, a retention of suitable import duties to be paid by all alike. The unreasonable duty-free privilege, which discriminates against American manufacturers in favor of Europe and Asia, must be abolished. Then this healthy growth can be retaineed as a permanent branch of the glass industry in America.

Substituting Imported With Domestic Clays

In the past few years, many types of clay have been found in South Carolina and Georgia. Unfortunately, no suitable descriptive nomenclature other than Dry Branch, Gorden, Langley etc. has come into trade use. As the past geological experiences of a clay deposit controls the physical properties of the clay and no two deposits have been subjected to identical conditions, it follows that some judgment must be exercised in selecting a clay having properties similar to some particular foreign product.

Recent Developments in the Manufacture of Chemical Porcelain

By John C. Bailar

Soon after the outbreak of the present war, when German commerce was swept from the seas, any man who had a piece of chemical porcelain "Made in Germany" was inclined to keep it under lock and key. It would be decidedly inconvenient to run a laboratory without it and no one knew when or where more could be obtained when the supply on hand should be exhausted. But unknown to the scientific world the seeds of the chemical porcelain industry had already been planted in this country.

In the winter of 1910 a potter went to Golden, Colorado, seeking health. In order to pay expenses, he repaired an old pottery kiln that had long been in disuse and began the manufacture of cooking utensils on a small scale, he being the only workman in the plant. In 1911, the writer, struck with the excellent quality of the ware, suggested that he try some chemical porcelain. A few small crucibles were made using the same body and glaze that were used in the cooking ware. These were taken into the laboratory and given a thorough working test. As was to be expected, some of the test samples failed utterly, while a few compared favorably with the Royal Berlin porcelain that was in general use at the same time.

This showed the possibility of making good laboratory ware of the clay, and experiments were carried on in connection with the routine work until 1914, when the business was taken over by a company organized by Mr. Adolph Coors. The plant was enlarged as rapidly as possible, and early in 1915 was given over exclusively to the manufacture of chemical and scientifc porcelain. That the venture has been a success is attested by the fact that the company now has twelve large kilns running at full capacity. This company maintains a large research department and the policy has been to perfect one article before beginning another. For example, in the beginning, only small crucibles, casseroles, and evaporating dishes were made and not until these were of the very best quality did the research department turn its attention to anything else. The high quality of the ware is due largely to this policy. The brain power of the entire force is focused on each article before it is given to the public.

Aeroplane Spark-Plugs

The research department, under the direction of W. J. Hazard, is now concentrating on a porcelain spark-plug for aeroplanes. The object sought is a spark-plug that will stand up under fifty hours' continuous use, besides being resistant to hard knocks and having several other properties desirable in spark-plugs. Present indications are that this plug will soon be on the market. The best porcelain aeroplane spark-plugs now in use are good for about thirty hours.

Coors chemical and scientific porcelain is now sold by practically every dealer in the United States, as well as in the principal cities in Canada, Mexico, South America and the war zone in France. The company manufactures all the wares used in the laboratory and plant, and stands ready to make any special apparatus according to specifications. Special mention should here be made of the porous ware made by this firm. In comparative tests made in the United States mint, this ware lasted five times as long as the Royal Berlin. Some electrolytic processes have been completely revolutionized by the use of Coors porous vessels.

Local Materials Used

The materials used by the Coors Company, except a small per cent of the glaze, are found within five miles of the factory. The clay is of the same formation as that from which the Golden fire-brick and assay crucibles are made. Concerning the latter ware a writer once made the following statement[1]: "Mining engineers are in darkest Africa, in central China,, in the plateaus of the Andes and the steppes of Russia, but they have not yet got beyond the zone of the Colorado-made assay crucible." This is not a figure of speech but a plain statement of fact. In 1916, owing to the peculiarities in freight costs of transportation companies, both English and German assay crucibles were offered in the western United States for a less price than was asked for the home product, made from Golden clay; nevertheless they found no sale. But perhaps fire-clay goods should not be included in chemical porcelain.

The Guernsey Co. Takes Up Chemical-Ware

In contrast with the Coors pottery, the Guernsey Pottery of Cambridge, Ohio, was well established at the beginning of the war. They were making, among other things, high-grade cooking utensils. Realizing that there would soon be a demand for laboratory porcelain, this company lost no time in making such readjustments as were necessary. The change from cooking utensils to chemical porcelain was not great and by the time the last cargo from abroad was unloaded, they were in the market with porcelain that showed better tests than any "Made in Germany." During the past year there have been substantial advances in both quantity and quality of Guernsey ware. They now advertise "more than three hundred different items," which number ought to give variety enough to satisfy the demands of the most exacting chemist. The products of the Guernsey and the Coors companies have been tested and approved by the U. S. Bureau of Standards.

If the need should arise, either the Guernsey or the Coors pottery could supply the needs of the United States, leaving nothing to be desired in either quality or quantity.

In addition to these two firms, other companies are turning their attention to laboratory ware and neither the analyst nor the manufacturer need have any fear of the future. It can safely be predicted that if any German laboratory ware should ever find its way into this country, it will be given the same reception that was given to German fire-clay goods in 1906.

Research Department,
Great Western Sugar Co.,
Denver, Colorado.

Scratches on the Ground.—Clay has been an important writing material throughout all the ages. The sheet of paper on which this is printed is essentially kaolin in a more convenient form than the bricks of the library of Ninevah.

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[1]Non-Metallic Minerals of Colorado, *Western Chemist and Metallurgist*, Vol. IV, page 330.

Chemical Stoneware*

Preparation and Selection of Materials, Acid-Resisting Tests, and Annealing Ware

By A. Malinovszky

THE manufacture of chemical stoneware is a separate and distinct branch of the ceramic industry. It is a branch that has received but scant attention in this country as most of this class of ware was imported. Now that importations have been cut off, it is essential that we produce chemical stoneware equal if not superior to the imported article. This must be done if the chemical industry is to continue its growth and supply us with the many chemicals that have heretofore been imported or made in limited quantity only.

Chemical stoneware is made in a great number of shapes and sizes, ranging from the simple evaporating dish to the most intricate arrangement of pipes and vessels and to containers of great size. It requires a skillful workman for building up these various shapes and the utmost care in handling and burning them; but more than anything else, it requires the close and careful attention of a competent ceramic chemist to make selection of raw materials, supervise mixture and manufacture, from grinding to firing and to vary the processes to produce ware that will fulfill the requirements of the particular use to which it is to be put. A good chemical stoneware should resist the action of hot and cold acids of all kinds (excepting hydrofluoric acid), be able to stand sudden changes in temperature, and be impervious to moisture.

The Selection and Mixing of Clays

It is the usual practice to mix different clays to produce a body similar in character to porcelain; therefore, mostly those stoneware clays are used which contain enough flux to produce, at a high heat, a body with a very close structure. If stoneware clays are not at hand, a low grade of fire clay can be substituted. The fire clay is burned at about 1400 to 1500 degrees centigrade, at which temperature the iron and other impurities will act as the flux; or the fire clay can be mixed with an impure clay which has a very low fusing point. In this case the fire clay serves as the skeleton to preserve the shape of the articles from deformation, whereas the impure clay serves as the flux which at a high heat binds the particles of the fire clay into an impervious body. Other cheap fluxes can be added such as lime, or furnace slag, since the color is of no great importance. In this latter case, there is a chance for the acid to attack the iron and subsequently the clay body, thus disintegrating the whole body to a sponge-like mass.

Great care should be taken to produce a uniform body, since this is very essential in the manufacture of chemical stoneware. The best result is obtained by mixing and blunging the mixture, or only the fusible part, which will be the fusible clay (preferably all the mix should be blunged), and by then screening in order to remove all coarse particles. The surplus water is then removed with the filter press.

It is very necessary to screen the clay and remove all the coarse particles, particularly when taping and faucets are required which must be made to fit tight. The spigot and faucet are usually made from the same material as the body, some manufacturers preferring to grind the material finer for the spigot and faucet than for the body. The joints in spigots or faucets have to be ground with water and sand or emery to make a close fit. If the coarse material is not removed, tight fitting of spigot or faucet will be impossible.

The body mix should be high in silica and yet plastic enough to permit the shaping of large pipes and vessels, such as still condensers, acid containers and other vessels used in the chemical industry. At the same time it should possess an interval of from 200 to 300 degrees centigrade between complete vitirification and deformation.

New Materials Successful

It is in this interesting field of ceramics, more particularly refractories and chemical stoneware, that the writer has been doing research work during the past several years of strife. The company with which I am connected has undertaken the development and perfection of processes by which certain waste materials and minerals, heretofore unutilized, can be employed in making various ceramic products.

It is gratifying to be able to say that our efforts have been successful. Many tests of the ware, both in the laboratory and under actual working conditions have given results comparable with the best imported products. Materials from many different states have been used in this connection and their suitability under the process proven.

The composition of the stoneware is highly vitrified and the ware has a structure similar to that of igneous rocks, excepting that it is more nearly homogeneous. It can be made of as close and fine grained a structure as porcelain. This stoneware consists of unfused and fused particles, held together by a vitreous bond. The different mineral particles are enveloped by the fused particles, giving a strong interlocking structure which resists the action of moisture and of acids.

Some Solubility Tests

A test made by the author in our own laboratory yielded some interesting results. Two crucibles and one vase were placed in a gas fired dry oven and were gradually heated for 72 hours to 110 degrees centigrade. After they were allowed to cool in the oven to 90 degrees centigrade they were placed in a large jar until cooled to room temperature and then were carefully weighed. The small crucible weighed 192 grams; the large one 934 grams, and the vase 621 grams. The crucibles and vase were immersed in water for 48 hours, then removed, and, after drying the surface with blotting paper, carefully weighed again. The results obtained indicated that the large crucible had 0.856 per cent absorption, the small one 0.521 per cent, and the vase 0.0325 per cent. The same crucible and vase were again dried and weighed as before. The large crucible was found to weigh 933.542 grams, the small one 192.000 grams, and the vase 620.372 grams.

They were then filled with commercial concentrated sulphuric acid, 66Bé., and the two crucibles placed on a 14-inch iron pan filled with sand. Two inches of sand separated the test pieces from the pan. Heat was ap-

*Read at the June meeting of the American Institute of Chemical Engineers, Gorham, N. H.

plied and boiling continued for a period of 12 weeks. The temperature of the sand and acid was taken day and night. The record shows an average temperature of 128 deg. C. Since we had no gas regulator at hand the temperature varied from 136 to 120 deg. C.

The vase was subjected to the same test, excepting that the flame was applied directly to the vase and was therefore more difficult to maintain at a constant temperature. Especially was this true during the night when the gas pressure was stronger than during the day. Forty-two pounds of acid were used, since the test pieces had to be filled whenever the acid fell below half the capacity.

After the twelve weeks boiling, the fire was turned out and the test pieces were allowed to cool. They were then washed some thirty times with brush and water, placed in a drying oven, heated to 140 deg. C., cooled and washed again, and placed in the drying oven and heated to 140 deg. C. They were then placed in a jar containing fused calcium chloride. After 24 hours they were removed and weighed with the following results:

	Grams Weight	Per Cent Loss
Large crucible	932.854	0.0737
Small crucible	192.000	.....
Vase	619.863	0.0981

One of the crucibles was then broken and reduced to a fine powder which was passed through a 16 mesh sieve and then through a 20 mesh sieve. One hundred of the largest grains remaining on the 20 mesh sieves were selected and thoroughly washed with distilled water, then dried to 110 deg. C., cooled in a desicator, and weighed. The 100 selected grains weighed 180 grams.

They were transferred to a platinum crucible and treated with the acid mixture of 10 parts of concentrated nitric acid, plus 25 parts of concentrated sulphuric acid, plus 65 parts of water. The platinum crucible with the contents of the 100 grains and acids was placed on wire gauze on which a ½-inch piece of asbestos 1½ inches in diameter was placed, and gently heated to boiling and held at that temperature until the water and nitric acid were vaporized and all sulphur fumes driven off. The whole operation took four hours. The crucible was then allowed to cool.

Water and nitric acid were again added and reheated to boiling and held for 10 minutes. The contents of the crucible were transferred to filter paper and washed thoroughly until the wash showed no acid reaction with blue litmus paper. It required about 1500 cc. of water to wash the grains free from acid. The grains were then dried in a drying oven to 110 deg. C. for five hours, then transferred to a desicator and weighed. The weight of the grains was 179 grams, showing a loss of 0.56 per cent.

The grains were then transferred into the platinum crucible, which was previously heated and weighed, heated for 20 minutes and blasted for 10 minutes, then cooled in the desicator. The loss shown was the same as before.

Micrographical Examination

Microscopic examinations were made of several samples by Professor Rolin B. Salisbury, geologist, University of Chicago, in order to determine the structure of the material and the composition of this stoneware after it is burned. The writer has also made microscopic examinations of many samples.

The examinations have shown that in all cases, in the vitrified composition, the burning has produced fusion enough among the materials used in making the ware to develop a glass as in lavas. It could be noticed on the slides that this glass served as a binding material for the original grains which were not fused. These grains were bound together by the glass in very much the same way as are the crystals of some igneous rocks by the glassy uncrystallized parts of lava.

In physical composition, therefore, this stoneware is like a compact igneous rock which is but partly crystallized. The texture of the body is such as to indicate the possibilities of a high polish, so that spigots and stoppers could be ground to perfect joints; and the grain is so fine and even that clean-cut lettering and carving is possible. This has already been proven very satisfactorily.

In describing the material, Professor Salisbury notes that "under the microscope the material is seen to consist of grains of quartz, orthoclase, magnetite, and altered ferromagnesia mineral in a glassy ground mass. This ground mass was developed in the burning and is the result of the fusion of parts of the substance of which the body is composed.

"The pore space is about eleven per cent, but it should be noted that this is not the amount of space that will take up water, since the pores are in the glass and not accessible to water. The grains of quartz are angular (many) or rounded (fewer), apparently as they were before burning. They show little, if any sign of corrosion. The corners of the angular grains remain sharp, but there appears to be a very thin film of clear glass surrounding each.

"The feldspar grains, both orthoclase and plagioclase, are much altered on the outside, and grade into the ground mass without sharp demarkation. The smaller grains are altered throughout. Under the microscope the original grains are seen to be broken up into extremely fine fragments which are bound together by isotropic material. The effect of the heat appears first to have fractured the grains and then to have fused the material along the cracks. The little particles into which the feldspar is broken average about 0.002 mm. in diameter. There appears to be considerable kaolin, probably such as occured in the original material from which the body was made.

"The ferromagnesia mineral is so much altered that its original character is not recognizable. But little of it is present. It is now altered to magnetite, surrounded by a brownish stain. It grades into the ground mass. The ground mass is of glass, filled with minute (.002 mm.) particles of quartz and feldspar. The union of the original particles seems to be as complete as in extrusive igneous rock which contains some glass."

It is interesting to consider the action which takes place between the alkaline earth and metals and oxides of silica, aluminium, and iron during the burning period.

When the fire is started, the hot air pauses through the kiln warming up the green particles; and when the temperature of 110 deg. C. is reached inside the kiln, the hydroscopic moisture is forced to leave the green ware, and at a higher temperature the chemically combined moisture is driven off and oxidation follows. When this

is completed the bases and the silica and alumina combine in order to form various silicates. Naturally the base which has the lowest fusing point will fuse first, reacting with the finest grains of silica to form silicates, and then, in order, follow the next ones which have a higher melting point, until all the required eutectic mixture is in a sufficiently glutinous state to bind all the non-fused particles with a glassy bond to a dense body.

At first the feldspar substance in the body begins to soften; the fused feldspar is then attacking the clay substance while it is melting. However, the melting point of feldspar must not be misunderstood. Feldspar does not melt to a liquid and flow, but only softens and adheres to the more refractory particles. It is well known that the greater the proportion of undissolved material present in the mixture, the longer the ware will resist deformation. This fact is proven by the hard translucent porcelain, where the potter builds up his frame work with kaolin to insure the articles against becoming deformed within the heat limit.

Cooling and Annealing

When the ware is sound and is vitirified to imperviousness, firing has ceased, and cooling and annealing commences. Annealing is a process of gradually cooling, which allows the silicates to settle and rearrange themselves in a condition of equilibrium. The annealing process is just as important in producing chemical ware as all of the processes in the manufacture of ceramics, to avoid molecular strain; yet it is the least understood by most manufacturers.

The importance of the annealing process is frequently to be seen in the case of glass tiles on sidewalks which have broken or disintegrated into powder. The reason lies in the fact that the glass, in the molten state, was poured into the steel mould and pressed. In this way the glass was chilled rapidly and the molecules on the surface rushed to adjust themselves. As a result, the glass becomes intensely solidified which prevents the molecules of the interior from rearranging and uniting. We can easily see that the glass is in a state of continual strain and is prevented from collapsing only by the intense rigidity of the exterior walls. As soon as the surface of the glass is scratched or broken, the whole tile breaks into pieces, sometimes making a violent noise. This is true with the stoneware also. If cooling is hurried too much, the ware will be brittle and invisible cracks will occur.

Cooling too slowly will cause too much of crystallization of the magna; therefore the cooling can proceed very fast until the temperature has fallen to red heat—say 1000 or 800 deg. C.—when freezing temperature of the eutectic has been reached; from then on cooling has to proceed very slowly, especially when the body is high in silica.

A very good idea of the formations and behavior of the silicates in the glass or ceramic bodies can be illustrated as follows:

Let us imagine a dancing hall, everything quiet; all persons present are comparatively motionless. Some may be in a standing position eagerly waiting for action, others seated. The orchestra commences to play. Every one hurriedly looks for his or her partner and then the couples dance around the hall in greatest order, one pair after the other. We never find that all the persons commence to take action at once, but pair after pair until all are dancing, excepting the people on whom the catalitic action of the music has not taken effect.

As soon as the orchestra stops playing, the couples return to their places quietly and rearrange themselves orderly for the next action. Had there been any disturbance in the orchestra or among the dancing couples, the music naturally would have stopped at once and every pair would have parted in disorder, running unsettled in all directions. From this we learn that the orchestra had assumed the function of a catalyzer to produce action in the persons present in the dancing hall.

This is also true with the heat. When burning chemical stoneware, the heat is in reality not consumed; it only performs the action of forming the different silicates in order to produce vitrification in the ceramic bodies to make it impervious to moisture and acid. Thus we see that the function of the heat as a catalyzer is exactly the same as the music; every molecule of the heat is given up as soon as it has accomplished the required result.

Portland Cement Construction for Chemical Works

By Maximilian Toch

PORTLAND cement and the cements from which it has been derived have always shown a tendency to porosity and the necessity for either an added material or a coating in order to make it impervious has always been apparent. The Romans recognized the necessity for water-proofing Pozzuolan, the composition of which is quite similar to that of our Portland cement. Two thousand years ago they recommended the use of a small quantity of grease in order to water-proof their structures. Our rush to finish construction of all kinds demands the use not only of a water-proofing material but one which shall lubricate at the same time and overcome the shortcomings of the man at the mixer. For this purpose, there are two distinct types of water-proofing, both of which are patented, one practically composed of stearate of lime, free from glycerine, and the other composed of a glyceride of a fatty acid mixed with a colloid.

There are such vast quantities of nitre cake that are dumped into rivers and creeks near chemical works that the free sulphuric acid in the nitre cake has a tendency to dissolve out the Portland cement foundations of adjacent structures, and for this purpose, newer water-proofings for Portland cement have been invented which make the concrete relatively acid-proof, and after the forms have been removed, it has been found necessary to apply acid-proof coatings to such Portland cement foundations to prevent the disintegration from the acids that pollute the streams.

The scarcity of steel and the high price of lumber construction has done much for the progress in the building of Portland cement tanks for chemical works, the only feature being that special coatings have had to be devised, the kind depending upon the chemicals used. The thinner oils and many of the heavier oils cannot be stored in concrete unless the concrete is particularly dense and well finished, and even then it is not worth while taking a chance, but the application of an oil-

proof coating prevents concrete from being disintegrated. Even acids may now be stored in concrete tanks provided the tanks are finished with acid-proof brick linings which have been set in a heavy bituminous binding material.

The great advantage of a Portland cement tank for chemical works is that, assuming that it is built correctly, it will last forever, and that of course cannot be said of a wood or steel tank.

There are some chemical works that use large quantities of nitre cake. I know of one concern that built an entire storage shed of acid-proof concrete for storing nitre cake, and it has proved that concrete can be made impervious to acid, a feat which was regarded as impossible before the war.

The Journal of the American Ceramic Society

A journal that is a pioneer in its field is always the subject of most careful scrutiny. When that field is representative of one of the oldest phases of human endeavor the cause for attention to the new publication is multiplied many fold. There has now appeared the first issue of the *Journal of the American Ceramic Society*, a monthly journal devoted to science and technique of the ceramic industries.

The American Ceramic Society belongs to the older family of scientific societies in the United States. The first meeting of the society, which was in reality a little family gathering of a small group of ceramic enthusiasts, was held in Columbus, Ohio, in February, 1899, and from that meeting grew the present organization due largely to the guiding genius of Prof. Edward Orton, Jr., of Ohio State University. The society is, therefore, in its twentieth year of vigorous and active life. The membership has increased from that early day until at present there are over a thousand enrolled.

In the American Ceramic Society, the term ceramic is synonymous with "silicate industries" and the interests and activities of the society include all branches of the clayware, glass and cement industries as well as enameled wares of all kinds and in addition other closely allied products are included, chief among which are abrasives, gypsum and lime. Few people realize the gigantic proportions of these ceramic industries. The products of the three major divisions alone (clayware, glass and cement) aggregate over $400,000,000 per annum.

In the earlier days the society consisted of one main organization only. With increased activities and with enlargement in its scope of usefulness it became necessary to organize Local Sections for the following localities: St. Louis, Chicago, Central Ohio, Northern Ohio, West Virginia, Beaver, New England, New York State, New Jersey, and Pacific Coast.

Student Branches exist in Ohio State University, New York State, University of Illinois, Iowa State College.

The publication work of the society has, up to the present time, been confined to the issuing of its annual volumne of *Transactions*. Twenty years ago this was a small, feeble effort, very creditable for the then existing state of our knowledge of the science of the silicate industries. This annual volume has shown continuous growth and the 1917 volume comprises 707 pages of well-edited contributions. The American Ceramic Society's *Transactions* have been known for many years throughout the world as the standard reference books on the silicate industries.

This remarkable growth in strength and influence of the society has made it essential that periodical publication of the researches and other activities of the society members be undertaken and the monthly *Journal of the American Ceramic Society* is the logical result.

The first number is a very attractively prepared journal of seventy-two pages. It is well edited and well printed on good paper. The contents of the first number are as follows:

Editorials:
- To the Public.
- The Fuel Curtailment Orders.
- The National Research Council.
- Edward Orton, Jr.

Original Papers and Discussions:
- Kaolin in Quebec—Keele.
- Special Pots for the Melting of Optical Glass—Bleininger.
- The Effect of Gravitation Upon the Drying of Ceramic Ware—Washburn.
- Test of a Producer Gas-Fired Periodic Kiln—Harrop.
- Notes on the Hydration of Anhydrite and Dead-Burned Gypsum—Gill.
- Meetings of the Local Sections, American Ceramic Society.

The present officers of the society are: President, Homer F. Staley; vice-president, A. F. Greaves-Walker; treasurer, R. K. Hursh, and secretary, Charles F. Binns. Trustees: A. F. Hottinger, E. T. Montgomery, R. D. Landrum.

Membership in the society is open to anyone interested in any branch of the ceramic industries and application should be made to the society. All members receive the *Journal* gratis; to non-members the subscription price is $6.00 per year (12 issues), payable to the secretary in advance.

Graphite Supplies For 1918

About 30,000 tons of graphite suitable for crucible manufacture will be needed in 1918. If freight and market conditions and an improved labor situation favor the shipment of domestic graphite about 8000 tons of flake of crucible grade, exclusive of dust, can be marketed in this country in 1918, an increase of more than 100 per cent over the production in 1917. If the freight conditions that prevailed in the autumn of 1917 should recur the domestic production of No. 1 and No. 2 flake will hardly exceed 2500 tons. If the domestic production could be stimulated to its maximum capacity, reasonable assurance of a steady market given, and encouragement offered to new plants a production as high as 12,000 tons might be reached. The situation is more favorable with respect to noncrucible graphite. The requirements for 1918 will be between 28,000 and 31,000 tons, which may probably be supplied by domestic, artificial, and Mexican production. Amorphous graphite was produced in 1917 by five mines in Colorado, Michigan, Nevada, and Rhode Island. The production was 8301 tons, valued at $73,481, compared with 2622 tons, valued at $20,723, in 1916.

Carborundum Refractories

A Comparative Account of Silicon Carbide Refractories With Those in General Use—Great Improvement Made in Thermal Conductivity, Efficiency and Strength

By S. C. LINBARGER, B. S., Cer. E.

EVER since its inception, one of the vital problems of the ceramic industry has been the question of suitable refractory materials, both for use in its own factories and as a product which will meet the demands of the other industries which require the highest grade of refractories. These materials must have sufficient strength under normal conditions to carry the weight of the structure of which they are an integral part and must, furthermore, have sufficient refractoriness to carry this same load under the extreme heat conditions to which they are subjected.

It has always been customary to regard heat insulation in a refractory material equally desirable with resistance to fusion, probably because these properties are intimately associated in the case of the common type of fire brick or sagger mix of the aluminous silicate type which are highly refractory and are such poor conductors of heat that in comparison with metallic substances they can safely be classed as heat insulators. However, only a superficial study of the problems involved in the burning of ware in saggers or muffle kilns reveals the fact that heat conductivity of the refractories used, besides being highly desirable, is a potent factor in the economical operation of the process.

For many years men connected with all branches of the clay working industry have been seeking a more effective means of burning clay products in a shorter time and with less fuel. Especially is this true and the need for it was never greater than at the present time when the vital needs of the country must be met with a maximum of fuel economy. Most of the efforts have been along the line of improving kiln design so that the maximum amount of heat is extracted from the gases of combustion before they pass into the stack. In most cases this is accomplished by passing the gases from the hot zone or chamber over ware in other zones which is at a much lower temperature and thereby gradually raise the temperature of the ware by the utilization of the sensible heat of the gases after they leave the combustion zone. All agree that when ware is being burned at a high maturing temperature one of the vital points of fuel economy is to get as much as is possible of the heat of the gases transferred from them to the ware.

In the pottery and allied industries where the ware is burned in saggers or by setting on shelves or bats a solution of this problem resolves itself into the proper selection and utilization of a refractory material which will more quickly and more easily absorb the heat from the surrounding gases and transmit and deliver it to the center of the bearing structure. The essential physical properties which govern the selection of the best refractory for this purpose are strength, specific heat, thermal conductivity and emissivity. Of course in connection with these it must have the required refractoriness and be able to withstand the necessary handling without breakage.

The element of strength, both transverse and compressive, is one of the properties which is too often overlooked in the selection of the proper refractory material. By using a material of high mechanical strength, both under normal and heat conditions, not only is the loss by breakage materially reduced, but primarily the walls of the building material can be very much thinner, with the consequence that the heat is conducted to the ware much more readily, to say nothing of the saving in kiln space and the smaller amount of heat required to bring the building material up to the maturing temperature of the kiln.

The specific heat of the refractory is the important physical property required in calculating the number of thermal units that are really wasted in bringing the large mass of the supporting material from normal temperature up to the finishing temperature of the kiln. In some instances where the weight of the bats and saggers is equal to or more than the weight of the ware which it protects and supports, it means a considerable item in the burning costs.

As a concrete example of the exact factors involved in the transfer of heat from the hot kiln gases to the ware, let us consider the specific case of a plant which is burning ware in saggers, the saggers being set in stacks so arranged in the kiln that their entire peripheral surface is exposed to the kiln gases. The spaces between the sagger stacks can be assumed to be chimneys and the velocity of the gases through them will depend upon their size and shape and also upon the draft of the kiln. Assume the hypothesis:

1. That the turbulence is such as to make a fairly uniform temperature in the kiln at any point on one of a system of surfaces which is symmetrical about the gas passage; and

2. That the average temperature on these surfaces is the average of the temperature of the gases at ingress and egress.

It is evident that these hypotheses mean that the turbulence is controlled by some finite law that a graph indicating the temperature gradient through the kiln would be a straight line. These hypotheses hold fairly well if the motion of the gases is so slow as to make the turbulence negligible or if the motion of the hot gases is so great as to make the turbulence very great. The quantity of heat then that will pass through the walls of the supporting refractory medium in a given time and be delivered to the center of the saggers will depend upon the excess temperature of the gases over the

ware and the thermal conductivity of the refractory and will be a direct function of the emissivity of it.

When heat waves strike a body some of them are absorbed and some of them reflected unless the body be what is known as a "black body," in which case all of the heat rays are absorbed. All other bodies absorb a definite percentage of the heat waves which strike their surfaces and reflect the rest. The exact ratio of conduction and radiation being dependent upon the surface and the character of the body. This ratio for any material is what is known as the emissivity factor of that material. Under like conditions the same ratios hold true for the radiation of heat units from any solid body into a gaseous medium. The emissivity factor for any substance can then be determined experimentally by finding the radiation per second per unit surface area per degree difference in temperature. As the quantity of heat that will cross the boundary plane between the solid and the gas per unit time is dependent upon a factor other than the thermal conductivity of the solid, it is readily observed that the emissivity factor of the refractory which is usually neglected is an important consideration in the absorption of the greatest amount of the sensible heat from the gases which come in contact with it.

Crystallized silicon carbide or "carborundum" as it is most commonly called has long been recognized as having unique physical properties which make it peculiarly adaptable in the construction of highly refractory materials. However, up to the present time it has not had a very wide application in this field owing to its high price and also to the lack of sufficient quantities to supply other than the abrasive industry, which of course is its field of primary importance.

At the present time there are two types of crystallized carborundum refractories which have been highly developed. The first type which goes under the trade names of "Refrax" and "Silfrax," depending upon whether the crystallization of the aggregate is large or small, is made according to patents which in general cover the silification of mixtures of carbon and silico carbide or carbon forms and their subsequent conversion into carborundum by subjecting the carbon to silicon containing vapors at the heat of the electric furnace. The carbon is converted into carbide of silicon forming a dense interstitial binder or matrix between the crystals. Of course there are many modifications of this process but the essential characteristic of this type of refractory is that the final products obtained are pure silicon carbide.

The other type which is known as "Carbofrax" is the type most generally applicable for use in the ceramic industries. It is made by bonding graded crystallized carbide of silicon grains with various percentages of a mixture of special refractory clays or other bonding substances.

When bonded with even a high percentage of clay binder, brick which contains carborundum gives very great refractory values. However, since the refractoriness of a conglomerate refractory mass is a direct function of the amount and character of the least refractory constituent, it is recognized that the ideal condition to be obtained is that the amount of binding material used be the least consistent with the requisite strength; and that the vitrification temperature of the binder be as high as is commercially practical. Mixtures of grits and methods of bonding are employed which insure a very dense body of low porosity with but a minute percentage of refractory clay binder and at the same time allow the manufacture of large and intricate shapes.

Experimentation has shown that crystalline silicon carbide forms at 1840 deg. C. and dissociates at 2240 deg. C. into its elements, the silicon being volatized and the carbon remaining as graphite. No softening or fusing occurs below the dissociation temperature which is shown by the sharp and perfect forms of graphite pseudomorphs or skeletons which are left when silicon carbide dissociates. This is in direct contrast to most other refractories such as silica, chrome, and fireclay brick which soften at a temperature several hundred degrees lower than their fusion point.

Fig. 1 shows the emissivity curves of several common refractories. The curves for this factor were accurately

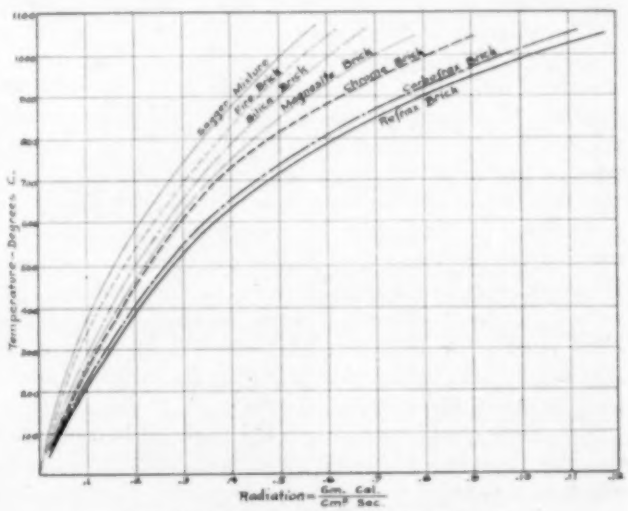

FIG. 1.—HEAT EMISSIVITY CURVES

plotted from results obtained by very complex experimental methods which are too cumbersome to describe in this paper. It will be noted that the emissivity of both classes of crystallized carborundum brick is much higher than either magnesite or chrome brick and almost double that of clay brick at a temperature of 200 deg. C. and higher.

TABLE I.

Material	Specific Heat	Thermal Conductivity	Compressive Strength, Lb. per Sq.In.
Fire brick	0.192	0.0034	1,050
Sagger mix	0.187	0.0033	1,340
Magnesite	0.220	0.0071	4,800
Chrome	0.174	0.0067	3,900
Refrax	0.162	0.0275	12,500
Carbofrax	0.180	0.0243	14,700
Silica	0.191	0.0020	2,300

Table I shows the results of some tests made on the most common types of refractory materials. The specimens tested were selected at random as being representative of the average product of that particular class of refractory. No attempt was made to compare different brands of the same material.

A comparison of the thermal conductivities of the materials reveals the fact that the carbofrax brick will conduct about three times as much heat as magnesite, seven times as much as the sagger mix and twelve times as much as a silica brick in the same period of time.

Fig. 2 graphically represents the relative efficiencies of various refractory materials as obtained by using the values of specific heat, thermal conductivity and emissivity in the formula for the law governing the transmission of heat from a gas to the interior of a solid body. The figure is arbitrarily based with the abscissæ representing relative efficiencies while the ordinates give difference of temperature. A study of the results demonstrates that the materials with a high emissivity factor and high coefficient of heat conductivity show several times the efficiency of those with correspondingly lower values with the same thickness of wall. Compressive tests of the materials show that the carborundum refractories have a load-carrying capacity over ten times as great as the sagger mixture under normal temperatures. Under heat conditions this ratio is considerably increased because there is absolutely no softening of this class of material at 1350 deg. C. while the sagger mix at the same temperature shows a deformation with a load of 50 pounds per square inch. In fact, blocks of bonded SiC are used as bearing blocks in making load tests on refractories at high temperatures. It would then be possible to use refractories for supporting ware in kilns with walls one-tenth as thick as is ordinarily used with the aluminous silicate type of refractories. Since the amount of heat transmitted by a solid is inversely proportional to its thickness, the efficiency already demonstrated by high thermal conductivity and emissivity would be multiplied by ten.

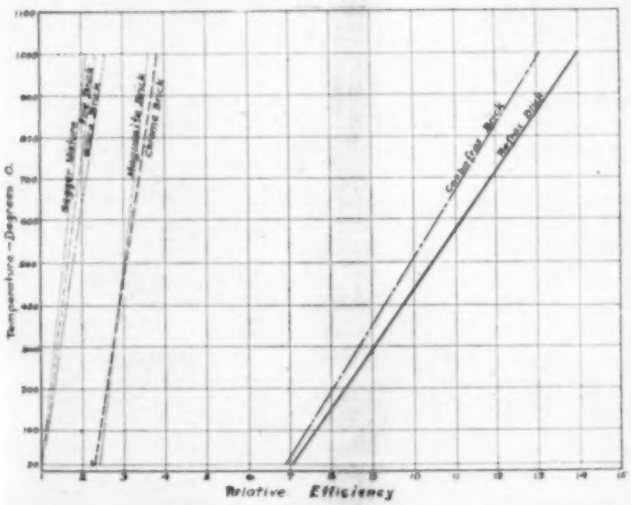

FIG. 2
RELATIVE EFFICIENCIES OF REFRACTORY MATERIALS

Aside from the importance of fuel economy, high thermal conductivity and heat capacity of crystallized carborundum impart to refractories made from it the property of withstanding the most sudden temperature changes because any variance in the temperature of the surface is quickly communicated to the whole mass and the heat is rapidly dissipated. Thus, the molecular work resulting from it is uniform and refractory shapes of this type can be subjected to the most sudden variations of temperature without being cracked or disintegrated.

As silicon carbide is not subject to any molecular changes being formed at 1850 deg. C. in a crystalline state and has an extremely low coefficient of expansion, no porous structure is necessary and a high density can therefore be obtained. This is not possible with most refractories since they contain ingredients which have one or more allotropic forms and must be made open and porous to successfully withstand the internal stresses. The low coefficient of expansion and high density of carborundum brick permit the construction of solid structures in places where the leakage of heat and gases through cracks in the walls due to alternate contraction and expansion is a detriment to the successful operation of the process.

In an effort to obtain the complete combustion of a fuel there is a growing tendency to increase the temperature of the fireboxes or furnaces. Ordinary firebrick, even of the best grade, fuses under the high temperatures developed and is attacked by the fluid ashes of the coal. This fluid ash which si violently attacks fireclay brick forms a brownish coating or glaze over the exposed portion of the carborundum brick which is unattacked by any additional fluid ash which is formed in the firebox. Owing to their extreme hardness this type of brick does not suffer from deterioration as the common refractories do when struck by the tools of the fireman during the process of cleaning the fires.

Carborundum is manufactured by passing an electric current through a mixture of sawdust, sand and coke in a long rectangular resistance furnace. By the utilization of an enormous amount of electric energy, the central portion of the furnace is brought up to about 2200 deg. C. at which temperature the silica is volatilized. One molecule of silicon combines with one of carbon forming a core of pure crystallized SiC or silicon carbide between the electrodes in opposite ends of the furnace. Immediately surrounding this is a zone of the amorphous variety of carborundum which is commercially known as firesand. Chemically it is a mixture of several silico-carbides which vary in composition from Si_2C_2O to Si_4C_4O. This represents a partial reduction of silica by carbon or a solid solution of silicon carbide in silica.

This material is also highly refractory but owing to its lower heat of formation and lack of definite crystalline structure it is not as stable under extremely high temperature as the crystalline variety. However, it has a wide application in places where a higher degree of refractoriness is required than can be obtained in the best grade of fireclay brick.

Finely ground firesand when mixed with a bonding material such as kaolin or high grade plastic fireclay, makes a refractory which can be moulded in place or plastered over the surface of a lower grade refractory to protect it from the cutting action of impinging flames. Owing to the fact that even the intense reducing heat of an oil flame does not cause any modification of the firesand, it has come to be a recognized material for the linings of brass furnaces of all types. It is also used as a protective coating for the brick work of furnaces, bag and baffle walls and the walls of potter's kilns. For this work it is mixed with water and sodium silicate, and oftentimes a small amount of clay to increase the adhesion, and applied to the walls in a slip condition. Refractory materials made of mixtures containing silicon carbide are now being used in various capacities in the ceramic as well as the metallurgical industries.

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"CENTRIFUGALS"

SOUTHERN PINE ASSOCIATION
SERVICE
SOUTHERN PINE ASSOCIATION
NEW ORLEANS, LA.
CHEMICAL UTILIZATION OF SOUTHERN YELLOW PINE

From A to Z With the Exhibitors

THE BALTIMORE COOPERAGE CO.: A complete line of miniature tanks which are exact reproductions of the larger sizes made for the chemical, drug and acid trade.

GENERAL FIRE EXTINGUISHER COMPANY—Grinnell sprinkler head in actual operation in a glass house or cabinet. At intervals a fire will be started on the floor of this cabinet which automatically opens the sprinkler head and releases the water, putting the fire out. Sprinkler supervisory service will also be illustrated. In charge of exhibit: FRANK V. SACKETT, HOWARD E. BRANCH.

GEORGIA CHAMBER OF COMMERCE—Through the courtesy of T. Poole Maynard, this organization will have a representative at his booth to give information regarding Georgia mineral products.

GORDON ENGINEERING CORPORATION—Two standard Gordon dryers, type B- and F-2. Since our entry into the war this company has developed a type of dryer for primers, detonators, explosives, etc., in use in Government arsenals. In charge of exhibit: HAROLD B. HARVEY.

GLENS FALLS MACHINE WORKS. Demonstration of a rotary sulphur burner; the Wood's machine, used as a save-all or washer for gun cotton as well as wood pulp; and a consistency regulator for regulating consistency of any kind of pulp. In charge of exhibit: JAMES H. HAINES, FRED CHAFFEE and M. G. TIBBETTS.

EMIL GREINAR COMPANY. A display of chemical glassware manufactured in the company's own plant in New York City, including accurate graduated glassware, burettes, pipettes, flasks, cylinders, thermometers, hydrometers and apparatus for gas analysis. In charge of exhibit: FREDERICK KRAISSE, PAUL TODTSCHINDER.

GROCH CENTRIFUGAL FLOTATION, LTD.: A working model illustrating this system of flotation as applied to the treatment of valuable mineral-bearing ores. This system and appliances have been developed since the war. In charge of exhibit.: FRANK GROCH, L. W. LEDYARD, W. E. SIMPSON.

GUERNSEY EARTHENWARE COMPANY—A complete line of chemical laboratory porcelain consisting of crucibles, casseroles, evaporating dishes, dry pots, concentric rings, desiccator plates, funnels, combusted boats, mortars and pestles, porous plates, retorts, etc. In charge of exhibits: ALLEN L. GOULDING.

HANOVIA CHEMICAL AND MANUFACTURING COMPANY—Apparatus for heat measurement and control; thermoelectric pyrometers, new model indicators and recorders, thermocouples, protecting tubes, central control and signal-system units, standardization equipment. Electric resistance thermometers, indicators, testing sets, thermometer bulbs. Electric furnaces and Impervite porcelain. The new developments of this company since we entered the war are new model pyrometer indicators and recorders and Impervite porcelain. In charge of exhibit: R. W. NEWCOMB.

HARDIDGE CONICAL MILL COMPANY—Working model of a Hardinge mill together with a large size glass model to show the interior workings. There will also be on exhibit a sample of Hardinge WB lining which permits lining a mill without exposing any of the bolt heads to the action of the balls. In charge of exhibit: E. W. LAWLER.

HAUSER-STANDER TANK COMPANY—A standard rectangular tank with sides and bottom cut out to show the method of rodding and bracing. A special type of crystallizing tank will also be shown with a few staves removed to show the interior arrangement. In charge of exhibit: S. HAUSER, JR.

HAYNES STELLITE COMPANY—Standard bar stock and bits, lathe tools of the arc-welded type, followed and inserted two milling cutters, end mill and some miscellaneous lathe tools. There will also be exhibited some products of the instrument and cutlery department, including surgical and dental implements, table knives, forks, spoons, ladles, pocket knives, mirrors, saws, etc. The new developments of this company since the war began consist of surgical instruments furnished the War Department. In charge of exhibit: ROE L. JOHNSON, H. S. DUNHAM, T. C. EDWARDS.

HELLENIC CHEMICAL & COLOR COMPANY, INC.—A line of dyestuffs, dry colors and some chemicals. This company has developed several colors since the war began, which were formerly imported from Germany. In charge of exhibit: MESSRS. WILLIAMS AND HAWTOF.

FRANK HEMINGWAY, INC.—Dyestuffs, mill supply specialties, intermediates and chemicals. This exhibit will feature a new stripping compound and a perfect substitute for cream of tartar for all but edible purposes. In charge of exhibit: T. F. O'KEEFFE, H. H. FOSTER, H. ARMBRUSTER.

S. S. HEPWORTH COMPANY—Belt-driven and electric centrifugal machine in operation. The electric type is particularly adapted to chemical plants requiring a machine of large capacity but not running continuously. This machine has been developed for special service since the entry of our country into the war. In charge of exhibit: BRUNO C. LECHLER, CHARLES A. ALCOTT, FOSTER E. BABBITT.

HERCULES ENGINEERING CORPORATION—Illustrations of a general line of chemical apparatus and the Hercules chlorine compressor. In charge of exhibit: R. D. KEHOE.

THE HERCULES POWDER CO. Samples of chemical products such as pyroxylin solutions, water-proof belt cement, lacquers, aëroplane dopes, together with samples of kelp from which solvents and potash are extracted; samples of potash fertilizer. On Wednesday morning motion pictures and slides of the harvesting of kelp and views of the plant where it is refined will be shown. The products resulting from the treatment of kelp have all been developed since the beginning of the war. In charge of exhibit: G. C. O'BRIEN, A. H. DEAN, J. H. RILE, J. P. BUTLER and C. A. HIGGINS.

HEROLD CHINA AND POTTERY COMPANY. Demonstration of porcelain ware, American made, showing how it will withstand heat and sudden changes of temperature.

HOLLY PNEUMATIC SYSTEMS, INC.—Pneumatic conveying installation with a suction dust filter, demonstrating the possibility of conveying pneumatically and economically all material from units not over 1½ in. in diameter down to material as fine as dust. Experiments are under way on a large scale for the recovery of pot-

ash from cement kiln gases. In charge of exhibit: L. F. HOLLY.

HOOKER ELECTROCHEMICAL COMPANY—Chlorine products. In charge of exhibit: Representatives from New York office and Niagara Falls plant.

HOSKINS MANUFACTURING COMPANY—Electric laboratory furnaces and hotplates; laboratory triangles, gauze and tongs; electric tool furnaces; recording and indicating pyrometers, thermocouples and thermocouple protecting tubes. In charge of exhibit: CHARLES S. KINNISON.

HOWES PUBLISHING COMPANY—An exhibit devoted to the American Dyestuff Reporter. In charge of exhibit: A. P. HOWES.

HUFF ELECTROSTATIC SEPARATOR COMPANY—An electrostatic separating machine or the treatment of ores of graphite, zinc, tungsten, manganese, copper, molybdenum. During the exposition the machine will be in operation on the treatment of various materials which may be submitted for preparation or concentration. In charge of exhibit: H. B. JOHNSON.

HUNTER DRY KILN COMPANY—Compounds of different kinds of rubber dried and processed by the Hunter system. Photographs of various installations. In charge of exhibit: HARRY HUNTER, OREN M. RAGSDALE, ARTHUR B. STONEX.

F. C. HUYCK & SONS. This company has specialized in woolen cloths for mechanical purposes, particularly the paper making trade, and in conjunction with the development of the chemical and dye industry in this country during the war have turned their knowledge of wool and machinery to the supply of woolen filter cloths which they will exhibit, showing the various stages in the production, and the materials from which they are made. In charge of exhibit: H. M. ASHBY, F. J. MCGOVERN.

IMPERIAL COLOR WORKS, INC.—An exhibit in conjunction with IMPERIAL DYEWOOD COMPANY and JOHN H. HEALD & COMPANY, INC. Dry and pulp colors and dyewood extracts; dry colors for the paint, printing ink, leather, textile and kindred trades; pulp colors for surface coating and paper mills; special dyes for wool dyeing and producing army khaki. In charge of exhibit: MESSRS. JACK AND CONSTANTINE.

IMPERIAL DYEWOOD COMPANY, INC. A display of dyestuffs in paste and crystal form showing the crude tropical woods from which the dyestuffs are made. In charge of exhibit: ROBERT CONSTANTINE.

INDEPENDENT CHEMICAL COMPANY. A display of heavy chemicals and acids which they manufacture for several companies. In charge of exhibit: O. CRISPENE, T. SULLIVAN.

INDUSTRIAL FILTRATION CORPORATION. Vacuum filters. In charge of exhibit: WM. H. HARDER, JR., W. H. LOUGHREY, HENRY B. FABER, H. W. CONRAD, J. R. HESS.

INNIS, SPEIDEN & CO. Display of chemicals and allied products.

JACQUES WOLF & COMPANY—Chemical specialties for the textile industry and dyestuffs. The following products have been developed subsequent to the war: Hydrosulphites, sulphur blacks, chrome black, gallient. In charge of exhibit: DR. ALFRED PFISTER, S. F. CARTER, C. E. HESSLING, WALTER DEUBLE, C. G. BOOTH.

JANNEY, STEINMETZ & COMPANY—Cold-drawn steel shapes suitable for the chemical industry, and hot-drawn high pressure cylinders for various gases and liquids under pressure. In charge of exhibit: N. W. SCHLATER.

JEWELL POLAR COMPANY—Steam, gas and electrically operated stills. A steam still in operation in connection with the Crane Company's adjoining exhibit. In charge of exhibits: A. C. JEWELL.

KALBFLEISCH CORPORATION—Mineral acids, metallic salts, paper makers' chemicals, alum, lacquers and thinners. The special features of the exhibit are permanganate of soda, sulphate of soda, anhydrous for standardizing dyes and colors. Among the products not made by this company prior to the war are permanganate of soda, alum, satin white and boro phosphate crystals. In charge of exhibit: V. P. DAVIS.

KALBPERRY CORPORATION, ENGINEERS—The investigation and determination of chemical investments. The design and operation of chemical plants. A recent development is a method of all-masonry construction for concentrating, Glover, Gay Lussac and denitrating towers and similar chemical construction in which leakage due to cracking has been obviated. In charge of exhibit: P. W. WEBSTER.

KEWAUNEE MANUFACTURING COMPANY—Chemical laboratory desks of various types; apparatus cabinets, fume hood, special plumbing fixtures and accessories for chemical laboratories. In charge of exhibit: O. T. LOUIS, CHARLES RESS, R. A. HANNA.

KEYSTONE MINERALS COMPANY—Rotten stone, Keystone black filler, velvet filler, mineral black. The new features of the exhibit are a fine grade of rotten stone and a new mineral black. In charge of exhibit: J. T. AND F. J. O'BRIEN.

KING CHEMICAL COMPANY—Sulphuric and nitric acids and sulphur dioxide. The latter was originally imported by this company rom Belgium but it has since developed a plant for the manufacture of this chemical. In charge of exhibit: O. CRESPERS.

MAURICE A. KNIGHT—General line of acid proof chemical stoneware apparatus. In charge of exhibit: MAURICE A. KNIGHT, CHARLES N. DENNISON.

H. KOPPERS COMPANY—Illustration of the essential features of the Koppers by-product coke ovens. Samples of coke and other fire products. The particular development of this country since the war began is the construction of a number of toluol recovery plants. In charge of exhibit: H. C. KIRKPATRICK.

LEEDS & NORTHRUP COMPANY—Electrical apparatus and equipment for the heat-treatment of steel, including the automatic signalling system used in connection with recording temperatures. Apparatus developed since the war began includes a portable a.c. galvanometer and an apparatus for the rapid electrolytic determination of carbon in steel. In charge of exhibit: E. A. KEELER, E. B. ESTABROOK.

ARTHUR D. LITTLE, INC.: Examples of the application of chemical engineering and chemistry to industries. In charge of exhibit: H. E. HOWE.

WALTER E. LUMMUS CO.: Continuous concentrating still, periodic column still, dissolving appartus, "metrolift," tower scrubber. Present activities practically

limited to war requirements, providing apparatus for solvent recovery, stills for benzol, toluol and naphtha, acetone and alcohol apparatus, evaporators and stills for products for poisonous gases. In charge of exhibit: C. F. TEARS, G. S. HOUGHLAND, J. T. STONE, E. W. BARTRAM.

EMIL E. LUNGWITZ: Kelly filter press, hand-operated and fitted with the latest automatic locks. A special Kelly filter press made of solid copper will be exhibited to show that these presses can be made of different metals for specific purposes. In charge of exhibit: C. L. BRYDEN, H. L. DICK, PAUL BARTELT.

LUZERNE RUBBER CO.: Hard-rubber specialties and standard goods. Items of interest to the chemical trade are hard-rubber piping, fittings, buckets, etc., for the handling of chemicals, acids and alkali solutions. In charge of exhibit: C. D. WILSON, HARRY E. CASE.

MACBETH-EVANS GLASS CO.: Chemical glassware, including beakers, flasks of various shapes and sizes, Petri dishes and covers, watch glasses, crystallizing dishes, funnels and moist chambers. In charge of exhibit: H. P. FULLER, J. W. HARVEY.

MARDEN, ORTH & HASTINGS CORPORATION: A full line of the dyestuffs and intermediates manufactured at the various plants of the company, samples of heavy chemicals and special brands of animal, vegetable, oriental and fish oils. Considerable attention attaches to this exhibit on account of the fact that many of the products were first developed in America by this concern.

MATHIESON ALKALI WORKS: Exhibiting jointly with Arnold, Hoffman & Company, Inc. Bleaching powder, liquid chlorine, caustic soda, soda ash, bicarbonate of soda and modified sodas.

T. POOLE MAYNARD: Geological, industrial and chemical engineering. Representing the Georgia Potash & Chemical Company, the Georgia Mineral Products Company, the Interstate Clay Company, the Southern Ball Clay Company. The Georgia Chamber of Commerce is at Mr. Maynard's booth, by courtesy. In charge of booth: T. POOLE MAYNARD, V. R. WAITE.

FREDERICK MAYWALD. Consulting chemist.

MENDLESON CORPORATION: Chrorinated lime, caustic soda and lye. There will also be on exhibition some of the small amber glass tubes each containing one gram of chlorinated lime, which are supplied to soldiers in the trenches for sterilizing drinking water. Each tube will sterilize a barrelful or field waterbagful of water and make it safe to drink. In charge of exhibit: J. M. STEMLER, P. E. ERHORN, J. E. SAMMOND.

MERCK & CO.: Medicinal chemicals and chemical reagents for use by physicians and in chemical laboratories. The company's works at Rahway, N. J., have been considerably extended since the war began in 1914 and have produced for the first time a number of new products such as carbolic acid, salicylates, hydroquonine, aniline, nitrobenzine, acetanilid, acetphenetidin, resorcin, paranitraline, phenolsulphonates, betanaphthol compounds, paraphenylenediamine.

METALS DISINTEGRATING COMPANY. Exhibiting samples of zinc dust, aluminum dust, tin dust and aluminium paint. Since the United States entered the war this company has developed on a large scale a process for the production of aluminium powder suitable for military purposes. In charge of exhibit: S. G. SCHATZBERG, W. H. NAUGLE.

B. MIFFLIN HOOD BRICK CO. Chemical stoneware of a hundred different sizes and shapes specially manufactured and adapted to acid-proof masonry construction. This material is suitable for the construction of towers, scrubbing towers, oxidation and denitration, also concentrators, Glover and Gay Lussac towers and tanks; spiral rings for tower packing. In charge of exhibit: B. MIFFLIN HOOD, J. J. NEER, G. BERGEN FORD.

MINE & SMELTER SUPPLY COMPANY. Massco clay goods and refractories made from Colorado clays; McCool pulverizer used for pulverizing assayed samples, chemicals, coal, etc.; Samson laboratory crusher; Lindsay low-pressure oil burner. One of the features of the exhibit will be a small Wilfley concentrating table, used for concentrating ores and for recovering and separating such industrial wastes as brass, copper and alloys. In charge of exhibit: J. SHEDDEN, E. S. TOMPKINS.

MINER-EDGAR COMPANY. Chemical products from the plant of the Seaboard Chemical Company and the Alcohol Products Company, manufacturers of wood alcohol and acetate solvents for special industries. Washed and floated clays for ceramic and paper uses. The chemical part of this company's business has been largely developed since 1914. In charge of exhibit: R. H. FRENCH.

MONARCH MANUFACTURING WORKS, INC. Stoneware sulphuric acid and chamber sprays in operation. The entire exhibit includes sprays in general, lead stop valves, lead check valves, lead syphons, furnace oil burners. The stoneware spray for nitric acid has been produced since this country entered the war. In charge of exhibit: T. W. MURPHY.

MONONGAHELA VALLEY TRACTION COMPANY. An exhibit of all products manufactured or mined in the company's territory; full information on bituminous coal, the most important resource; samples of glass-sand and coal pyrites. The West Virginia Geological Survey will contribute its library of state publications. The cities of Fairmount, Clarksburg, Parkersburg and Marietta will each contribute samples of their manufacturing industries. Important developments since the beginning of the war are the manufacture of gas and ammonium sulphate by the Lymn process, and the manufacture of sulphuric acid from coal pyrites. In charge of exhibit: For WEST VIRGINIA GEOLOGICAL SURVEY, PROFESSOR KRAK; for MONONGAHELA VALLEY TRACTION COMPANY, FRNACIS MCQUILLIN.

MULTI METAL COMPANY INC. Screens for bolting, sifting and filtration, made of brass, copper, bronze, phosphor-bronze, Monel metal, perforated metals. Pulmosan safety devices for the protection of workmen exposed to polluted air or poisonous fumes; helmets, breathing masks and respirators. In charge of exhibit: FREDERICK STERN.

NASH ENGINEERING COMPANY. Hydroturbine air compressors and vacuum pumps; Jennings turbine vacuum and low-pressure boiler feed pumps. The display will include pumps in actual operation. Special machinery devised to meet contingencies brought on by the war includes a successful chlorine compressor which, however, will not be exhibited. In charge of exhibit: IRVING C. JENNINGS, HOWARD M. WYLIE, G. B. WRIGHT.

NASSAU VALVE & PUMP COMPANY, INC. Acid-resisting valves, fittings, centrifugal pumps and castings for

hot or cold corrosive liquids, especially sulphuric acid and sulphates. In charge of exhibit: RAYMOND K. SNAVELY.

NATIONAL ANILINE & CHEMICAL COMPANY, INC. Exhibit of dyeings of American and German colors, both having previously been subjected to the same tests of scouring, pulling and exposure to light and weather. About 130 National dyes; a full range of intermediates; a quantity of dyed material and dyed garments of all descriptions; special dyeings of alizarine and indigo; a dyeing unit of a colorist's laboratory in which dyeings will be made on request. While the greater part of the dye exhibit represents developments since the war, special attention is called to alizarine and indigo. In charge of exhibit: L. J. MATOS.

NEW JERSEY ZINC COMPANY. An exhibit of products including various brands of zinc oxide, lithopone, ochre, zinc dust, zinc chlorine, (both liquid and fused), sulphuric and muriatic acids, as well as the newly developed U. S. P. zinc oxide now being produced in commercial quantities for the first time in the history of the country. Zinc cadmium and barium salts will be on exhibition, as well as samples of the finish which can be secured by the use of zinc pigments in paints. Among the metal products of the company are spelter, spiegeleisen, gold and silver bullion. The application of zinc dust in sherardizing and protective coating work will be illustrated. The production of U. S. P. zinc oxide for making pharmaceutical preparations is a new development, the output of the company at the present time being figured in ton per day. In charge of exhibit: W. H. HENDRICKS.

NIAGARA ELECTRO CHEMICAL COMPANY. Cyanides, exhibited in the booth of the ROESSLER & HASSLACHER CHEMICAL COMPANY.

NICHOLS COPPER COMPANY. Copper sulphate crystals; refined copper wire bar; pyramids illustrating the metallurgy of copper, containing ores, concentrates, blister, refined copper, silver and gold; pyramids of packages of Triangle brand blue vitriol; samples of gold, silver, selenium, copper oxide and nickel sulphate. In charge of exhibit: W. C. BENNETT and G. P. HITCHCOCK.

NITROGEN PRODUCTS COMPANY. Exhibiting jointly with ARNOLD, HOFFMAN COMPANY, INC. Sodium cyanide, lump and powdered, red and yellow prussiate of soda and anhydrous ammonia.

NORTON COMPANY. Comprehensive display of alundum and crystolm refractories and laboratory wear. Demonstrations will be made on a laboratory scale of physical and chemical properties of these materials. Apparatus of various kinds will be in operation. In charge of exhibit: HAROLD R. SAVAGE.

OHIO POTTERY COMPANY. Chemical porcelain ware, including beakers, casseroles, crucibles, evaporating dishes, filter plates, funnels, mortars, spatulas, etc. In charge of exhibit: GEORGE E. and C. D. FRAUNFELTER.

OLIVER CONTINUOUS FILTER CO. A small filter with accessories operating on cement dust from a potash recovery plant to show how every step on a continuous and automatic filter takes place; other types and accessories are also shown. Many types of filter have been manufactured since we entered the war for handling products not made in United States before the war. In charge of exhibit: E. L. OLIVER, R. G. WALKER, L. GAZARIAN.

ONTARIO BUREAU OF MINES. Ores and minerals from the Province of Ontario, together with chemical and metallurgical products of the same. Of special interest will be the exhibit of nickel and molybdenum ore, together with their metallurgical products. A wide range of metallic and non-metallic minerals will display the extent of the resources of Ontario. In charge of exhibit: W. K. MCNEILL, W. R. ROGERS, THOMAS W. GIBSON.

ORGANIC SALT & ACID COMPANY. Chemical products comprising salicylic acid, salol, sodium salicylate, acetylsalicylic acid, acetanilid, tri-phenyl phosphate.

PAGE STEEL & WIRE COMPANY. Samples of wire fabric for factory enclosures and fences. One sample will be made of American ingot wire and another of "Copperweld" wire. Copper-clad wire for electrical transmission has been widely used during the last year in the construction of cantonments. In charge of exhibit: W. T. KYLE.

PALO COMPANY. Laboratory supplies, including Durieux filter paper, Hess-Ives tint photometer, Despatch electric ovens, Link automatic water stills, Rhotanium. In charge of exhibit: M. J. SEAVY.

THE PFAUDLER CO. A display of acid-resisting, glass-lined steel tanks. A feature of this exhibit is a tank that has been used for boiling inorganic acid for one year and is still in good condition. In charge of exhibit: W. E. FOSTER.

PHILADELPHIA QUARTZ COMPANY. An exhibit showing the different forms of silicate of soda. In charge of exhibit: JAMES G. VAIL.

PHILADELPHIA TEXTILE MACHINERY COMPANY. Model of Proctor dryer for the drying of paints, chemicals, etc.; also samples of various paint colors and other materials being dried in the Proctor dryer. In charge of exhibit: W. R. MURRAY.

PNEUMERCATOR COMPANY. Various types of pneumercator equipment to demonstrate the method of measuring the weight, volume or depth of liquids contained in tanks. In charge of exhibit: WILLIAM THOMAS.

POWDERED COAL ENGINEERING & EQUIPMENT COMPANY. In actual operation, a small unit for burning powdered coal. The equipment is applicable to the firing of low-pressure and high-pressure heating boilers of the kind commonly used in apartment houses and small office buildings. It also lends itself to application in metallurgical work, forging, heat treating, etc. In charge of exhibit: H. B. PRUDEN.

PRECISION INSTRUMENT COMPANY. Apparatus for regulating and measuring the efficiency of combustion: CO_2 recorder; draft gages; flue gas analyzers. The particular feature of the exhibit will be an air speed indicator for aeroplanes which has been developed and produced since we entered the war. In charge of exhibit: ABRAM T. BALDWIN, C. E. CONWAY, and Messrs. VINCENT and GILSON.

PRODUCT SALES COMPANY. Industrial minerals such as acid tower quartz, feldspar, ground silica, barytes, crude and ground soapstone. A special feature of the exhibit will be chemically pure asbestos for laboratory use. In charge of exhibit: HENRY N. HANNA, Miss N. M. VOLOSHEN.